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1956, No. 3 COPEIA August 29

A Comparative Analysis of the Winter Feeding Habits of two Benthic Stream Fishes

FRANKLIN C. DAIBER

THIS represents one portion of a study of a small headwater stream typical of those found in western New York. It deals with the feeding habits of two benthic obligate fishes, the barred fantail darter, *Etheostoma f. flabellare* (Rafinesque), and the northern mottled sculpin, *Cottus b. bairdi* Girard, both simultaneously occupying the same habitat.

There have been many studies on the food habits of fishes (e.g., Forbes, 1888; Kraatz, 1928; Langford, 1938). Various aspects of the subject have been investigated, for example, the utilization of the limnetic crustacea for food by *Leucichthys artedi* (Langford, 1938) or the food of gars (*Lepisosteus* spp.) in relation to fisheries management (Lagler, Obrecht and Harry, 1943). Some investigators have attempted to ascertain the similarity in food between two species occupying the same habitat. Frequently they have been concerned with an economically desirable species versus one of little economic importance (Van Oosten and Deason, 1938; Clemens, 1950; Hunt and Carbine, 1950).

Forbes and Richardson (1920: 314) reported the stomach contents of six fluviatile individuals of *Etheostoma f. flabellare* to be two-thirds midge larvae; about one-fourth were small mayflies, and the rest were copepods. Turner (1921) found the stomach contents of 25 individuals to be primarily midge and mayfly larvae, almost to the exclusion of everything else. The occurrence of these two forms ranged from 80 to 100 percent; however, he made no attempt to distinguish between the various mayflies. Koster (1937) reviewed the feeding-habit studies of *Cottus b. bairdi*. His own work on 434 individuals demonstrated that the smallest sculpins subsisted primarily on dipteran larvae and small mayflies. These two forms decreased in value as the fish became larger, while the Trichoptera increased in importance. The caddis flies constituted approximately two-fifths, dipteran larvae slightly more than one-fourth and mayflies about one-fifth of the diet of larger sculpins. These three orders of insects comprised 89.2 percent by volume of the stomach contents of the sculpin, irrespective of size. The three recent papers by Dineen (1951), Zarbock (1951) and Bailey (1952) demonstrate the insectivorous diet of *Cottus b. bairdi*, *Cottus b. semiscaber* and *Cottus b. punctulatus* respectively, and especially the importance of the Diptera, Trichoptera, Ephemeroptera and Plecoptera. Except for Zarbock's paper, there was no distinction between species within the various insect orders regarding their relative importance in the diet of the sculpin. As will be shown in this paper, this is of some importance.

I should like to acknowledge my indebtedness to Dr. H. O. Burdick and the Alfred University Research Foundation for their encouragement, and for making funds available to carry out this project. Also I should like to thank the following men for their generous help in identifying some of the aquatic insects: Dr. E. M. Walker, Odonata; Dr. C. Betten, Trichoptera; Dr. S. G. Jewett, Plecoptera; Dr. J. S. Rodgers, *Dicranata* and *Tipula*; Mr. A. Stone, *Prosimulium*. Lastly, I wish to thank my students Wallace F. Henion, Frederick A. Kalber, and John W. Ropes who so willingly put in long hours and endured considerable physical discomfort in the field to complete the work.

DESCRIPTION OF THE HABITAT

This study was conducted on Vandermark Creek, a small tributary of the Genesee River, in Ward and Scio townships of Allegany County, New York. The stream has its origin in a wooded swamp and flows westward. It is approximately eleven miles long and has an average fall of forty-five feet per mile. The altitude at its source is 1,940 feet, dropping to 1,440 feet where the creek enters the Genesee River. The surrounding hilltops are each about 2,200 feet high and show a corresponding drop to 1,800 feet at the mouth. The upper part of the stream flows through brushy woodlands and overgrown fields. The principal trees are

willow and elm, with several pine plantings along the hillsides. The lower reaches of the creek flow through pasture and brush lands. Approximately three miles from the mouth, the stream has cut a gorge through the bedrock of sandstone and slate. The stream bed and surrounding hills are composed of a gravelly soil that is primarily glacial till in origin. The stones are thin and flat, varying in size from approximately one inch to eighteen inches in diameter, and up to three inches in thickness. In the last three miles of the stream there are large numbers of stones approaching boulder size. However, most of the stones in the stream bed are four to six inches in diameter, a characteristic feature of all the streams in the area. There are outcroppings of clay at intervals throughout most of the length of the stream and on some of the surrounding hilltops. These areas are distinguished by swamp conditions.

The stream is characterized by long shallow riffles only a few inches deep and pools that vary considerably in size. In general, the pools are long and relatively shallow, up to two feet deep. A few are large, more or less circular, and vary between five to seven feet in depth. They usually lie in the bends of the creek and are formed by the eddying motion of the water. A current is always perceptible even in the largest and deepest pools. There is considerable shifting of the banks and the stream bed because of the loose, gravelly soil. Bank erosion and the abrupt changes in the course of the stream markedly affect lotic conditions, especially in the lower portion of the creek. The greater amounts of woodland and pine plantings have a stabilizing influence on this erosion in the upper part of the creek.

Vandermark Creek, like all young headwater streams, is one of extremes. During the late fall and early spring, it is subject to the scouring action of waters from heavy rainfalls. During the late spring and summer months, the creek flows beneath the surface at several points. The extent of subsurface flow increases with a decrease in the amount of rainfall. The water is transparent and clears rapidly after flood conditions. Rooted aquatics are virtually absent. Most of the plant life consists of the sessile diatoms which cover the rocks with a greenish-brown layer. During the late spring there are large blooms of filamentous algae, principally *Spirogyra*, in portions of the lower part of the creek. It is believed that these blooms are enhanced by the drainage from the few barnyards bordering this portion of the stream.

The study area covered a half mile section of the stream in Ward township approximately three and three-fourths miles from its source. This area was selected because it lies entirely within a brushy woods and is not unduly subjected to human interference. The stream had not changed its course in this section during recent years and was therefore considered to be a reasonably stable area for the investigation. During normal flow, the stream width varied from two to forty feet, but averaged about twelve to fifteen feet. This portion of the creek consisted of long to short riffles interspersed with long, shallow pools and one large circular pool approximately six feet in depth. We were unable to sample the latter.

Methods

The collection period extended from October 12, 1951 through May 9, 1952. Sixteen collections were made during the afternoon hours and, whenever possible, at weekly intervals. However, there were a number of weeks during which it was not feasible to make collections due to flood conditions, or when the air temperature was far below freezing. Flood conditions were most evident during the months of December and February. On three occasions it was not deemed feasible to make collections because the collecting day came too soon after the recession of high water. This decision was based on the work of earlier investigators who reported the presence of abnormal conditions in comparable streams caused by the disturbing influence of floodwaters (Mottley, Rayner and Rainwater, 1939; Allen, 1941).

The fish were collected with a 4 × 4 foot "common sense" seine. The most efficient method of capture was to have one person hold both handles of the seine while another stirred up the rocky stream bottom for a few feet in front of the seine. The fish were immediately preserved in formalin. A collection of the bottom fauna was also secured with a stream-bottom sampler. Ten samples of one square foot each were taken during the first three collections, but all subsequent collections consisted of twenty samples. Each collection in-

cluded samples from the sides and middle of the shallow pools and riffles. A plankton net (125 meshes to the inch) was fastened to the back of the bottom sampler in such a way that it could be removed after each sample. This net was added in order to retain the chironomid larvae that were small enough to pass through the meshes of the sampler.

In the laboratory, the bottom samples were examined and each organism identified to the lowest practical taxonomic category. The results of all the samples were pooled together to

TABLE I

THE PERCENT FREQUENCY OF OCCURRENCE AND THE AVERAGE NUMBER AND WEIGHT OF ORGANISMS PER STOMACH FOR *ETHEOSTOMA F. FLABELLARE* AND *COTTUS B. BAIRDI* FROM 12 OCTOBER, 1951 THROUGH 9 MAY, 1952

(Weight is expressed in milligrams)

	Per cent frequency of occurrence						Average number and weight per stomach									
	E. F. flabellare			*Cottus b. bairdi*			*E. f. flabellare*						*Cottus b. bairdi*			
Stomachs with food	35	160	45	114	175	18	35		160		45		114		175		18	
Standard length, mm	16–26	27–40	41–52	16–31	32–51	52–72	16–26		27–40		41–52		16–31		32–51		52–72	
							No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Ephemerida																		
Stenonema sp.	11.4	10.6	13.3	11.4	20.6	11.1	.10	.60	.11	.70	.26	1.70	.13	.80	.21	1.40	.03	.20
Arthroplea sp.	5.7	13.8	24.4	5.3	1.7	—	.01	.03	.16	.30	.29	.60	.06	.10	.02	.03	—	—
Ephemera sp.	—	1.9	2.2	—	1.7	—	—	—	.01	.06	.03	.20	—	—	.01	.06	—	—
Isonychia sp.	8.6	3.8	8.9	—	2.3	—	.04	.20	.06	.30	.07	.40	—	—	.02	.10	—	—
Caenis sp.	—	2.5	2.2	—	1.1	—	—	—	.04	.03	.008	—	—	—	.02	.02	—	—
Iron sp.	—	7.5	17.8	—	—	—	—	—	.04	.20	.09	.40	—	—	—	—	—	—
Other	2.9	12.5	17.8	0.9	0.6	5.5	.06	.20	.07	.20	.13	.40	.01	.03	.003	.01	.06	.20
Plecoptera																		
Acroneuria lycorias	—	—	—	—	0.6	11.1	—	—	—	—	—	—	—	—	.002	.06	.08	17.80
Brachyptera sp.	20.0	18.1	15.6	13.1	22.3	5.5	.15	.80	.88	4.70	.26	1.40	.24	1.30	.45	2.40	.06	.30
Isoperla sp.	2.9	7.5	15.6	6.1	1.7	—	.02	.07	.03	.10	.07	.30	.05	.20	.19	.80	—	—
Other	8.6	3.8	13.3	—	1.1	—	.15	.06	.02	.08	.14	.60	—	—	.01	.03	—	—
Trichoptera																		
Helicopsyche borealis	—	—	—	0.9	1.7	11.1	—	—	—	—	—	—	.01	.04	.01	.04	.09	.30
Psilotreta frontalis	8.6	7.5	6.7	7.0	17.7	22.2	.07	1.70	.08	1.90	.03	.80	.08	1.90	.36	8.70	.63	15.00
Neophylax sp.	5.7	7.5	4.4	4.4	2.9	—	.01	.06	.10	.50	.05	.30	.02	.10	.03	.10	—	—
Philopotamidae	2.9	4.4	—	3.5	1.7	—	.006	.03	.07	.40	—	—	.03	.10	.01	.06	—	—
Limnophilidae	—	8.8	8.9	—	2.3	5.5	—	—	.05	1.10	.04	.90	—	—	.07	1.70	.02	.40
Other	—	0.6	4.4	2.6	6.9	5.5	—	—	.03	.30	.04	.50	.04	.50	.06	.80	.06	.80
Coleoptera																		
Coptotomus sp.	—	1.3	2.2	5.3	1.1	—	—	—	.008	.40	.02	.80	.04	1.40	.01	.50	—	—
Psephanus lecontei	—	—	—	—	—	5.5	—	—	—	—	—	—	—	—	—	—	.06	.50
Other	—	1.9	—	1.7	2.9	5.5	—	—	.006	.20	—	—	.02	.60	.02	.50	.13	3.50
Odonata																		
Ophiogomphus sp.	—	—	—	0.9	1.1	11.1	—	—	—	—	—	—	.005	.50	.01	1.30	.05	4.40
Diptera																		
Chironomidae	91.4	85.6	77.8	74.6	63.4	38.9	2.65	1.10	4.26	1.70	2.14	.90	2.07	.80	2.25	.90	.47	.20
Prosimulium hirtipes	5.7	11.9	31.1	0.9	16.0	5.5	.13	.40	.12	.30	1.25	3.60	.02	.06	.76	2.20	.19	.50
Dicranota currani	—	—	2.2	—	0.6	—	—	—	—	—	.04	1.50	—	—	.003	.10	—	—
Other	—	1.6	—	—	0.6	—	—	—	.008	—	—	—	—	—	.005	—	—	—
Insect remains	—	1.9	17.8	11.4	13.7	27.8	—	—	.23	—	.10	—	.19	—	.08	—	.03	—
Copepoda	28.6	7.5	6.7	4.4	0.6	5.5	.84	—	.36	—	.09	—	.07	—	.003	—	.13	—
Cladocera	5.7	3.1	—	0.9	—	—	.50	—	.07	—	—	—	.01	—	—	—	—	—
Amphipoda	8.6	2.5	—	0.9	—	—	.06	—	.07	—	—	—	.01	—	—	—	—	—
Orconectes sp.	—	—	—	—	1.1	—	—	—	—	—	—	—	—	—	. 05	—	.06	—
Isopoda	—	0.6	—	—	—	—	—	—	.005	—	—	—	—	—	—	—	—	—
Ostracoda	—	—	2.2	—	—	—	—	—	—	—	.02	—	—	—	—	—	—	—
Hydracnida	—	2.5	—	1.7	—	—	—	—	.03	—	—	—	—	—	—	—	—	—
Hirudinea	—	—	—	—	0.6	—	—	—	—	—	—	—	.01	—	—	—	—	—
Lamellibranchia	—	—	2.2	—	—	—	—	—	—	—	.006	—	—	—	—	—	—	—
Gastropoda	—	0.6	—	—	—	—	—	—	.005	—	—	—	—	—	—	—	—	—
Cottus b. bairdi	—	—	—	—	0.6	5.5	—	—	—	—	—	—	—	—	.003	—	.06	—
Total							4.80	5.30	6.92	13.50	5.17	15.30	3.11	8.40	4.62	21.80	2.23	43.30

obtain the total number of individuals for each species of organism and their total wet weights. These data then were reduced to the number and weight per square foot for each species. The average weight for each species was determined.

The standard lengths of the fish were recorded in the laboratory to the nearest millimeter. Only the stomachs were examined, for two reasons: identification of food organisms was more positive, and the stomach contents were assumed to be more or less representative of the last meal. Each organism was identified to the lowest taxonomic category and the total number of each per stomach was recorded. Since the stomach contents were in varying stages of digestion, it was not deemed advisable to weigh them. The weights for each organism in the stomachs were determined by multiplying the total number present by the grand average weight for the species computed from the bottom samples. The percent frequency of occurrence of a particular food organism was calculated by dividing the number of fish having ingested that organism by the total number of fish containing food items in their stomachs. The average number of each organism per stomach per collection was determined by dividing the total number of that organism eaten by the total number of fish having food in their stomachs. The average weight per organism per stomach was calculated by multiplying the average number by the grand average weight of the food organism computed from analyses of the bottom samples. The average number of each organism per stomach for the entire collecting period was computed by totaling the averages for each collection and dividing by the total number of collections (16). The weights per stomach were computed in the same manner. These procedures were based on the assumption that all the fish of the same size in any collection had had an equal chance to capture the available food items if that item were present in the stomach of any one fish.

TABLE II

THE COMPOSITION OF THE BOTTOM FAUNA OF VANDERMARK CREEK DURING THE FALL, WINTER, AND SPRING MONTHS OF 1951–1952

(Weight in grams)

Organism	Oct.–Nov.–Dec.		Jan.–Feb.–Mar.		Apr.–May	
	Wt./sq. ft.	No./sq. ft.	Wt./sq. ft.	No. sq. ft.	Wt./sq. ft.	No./sq. ft.
Ephemerida						
Stenonema sp.	0.0398	9.6	0.0072	0.7	0.0179	2.8
Arthroplea sp.	0.0186	9.6	0.0047	1.0	0.0040	1.5
Ephemera sp.	0.0231	3.2	0.0059	0.6	0.0010	0.3
Caenis sp.	0.0037	4.1	0.0008	0.8	0.0009	1.0
Isonychia sp.	0.0021	0.3	0.0012	0.3	0.0001	0.1
Iron sp.	—	—	—	—	0.0049	0.9
Traulodes sp.	—	—	—	—	0.0006	0.3
Other	0.0001	0.02	—	—	0.0002	0.1
Plecoptera						
Acroneuria lycorias	0.0086	0.1	0.0016	0.1	—	—
Brachyptera sp.	0.0042	2.7	0.0207	3.4	0.0002	0.01
Isoperla sp.	—	—	—	—	0.0069	2.3
Pteronarcys sp.	—	—	—	—	0.0015	0.01
Other	0.0010	1.0	—	—	0.0002	0.2
Neuroptera						
Sialis sp.	—	—	0.0001	0.02	0.0002	0.03
Trichoptera						
Helicopsyche borealis	0.0013	0.6	0.0001	0.03	0.0030	1.5
Psilotreta frontalis	0.0254	2.1	0.0097	0.3	0.0210	0.8
Neophylax sp.	0.0062	2.4	0.0012	0.2	0.0020	0.4
Philopotamidae	0.0212	8.0	0.0015	0.3	0.0024	0.8
Limnophilidae	0.0010	0.3	0.0063	0.5	0.0385	1.4
Other	0.0086	0.04	0.0475	0.2	0.0001	0.1
Coleoptera						
Coptoptomus sp.	0.0042	0.6	0.0001	0.03	0.0001	0.01
Psephenus leconti	0.0049	0.9	0.0038	0.4	0.0035	0.5
Gyrinidae	0.0115	0.5	—	—	0.0042	0.1
Other	0.0001	0.1	—	—	0.0018	0.1
Odonata						
Ophiogomphus sp.	0.0391	0.8	0.0143	0.1	0.0078	0.1
Diptera						
Chironomidae	0.0163	40.7	0.0049	12.3	0.0035	8.8
Dicranota currani	0.0182	0.6	0.0079	0.4	0.0075	0.2
Tipula sp.	0.0146	0.1	0.0838	0.2	—	—
Prosimulium hirtipes	—	—	0.0103	3.8	0.0022	1.7
Other	0.0004	0.1	0.0021	0.1	0.0004	0.1
Orconectes sp.	0.0322	0.04	—	—	0.1024	0.1
Hydracnida	—	2.8	—	0.4	—	6.1
Turbellaria	0.0026	0.4	—	—	0.0003	0.1
Oligochaeta	0.0007	0.1	0.0043	0.3	0.0002	0.1
Ostracoda	—	0.04	—	—	—	—
Total	0.3097	91.8	0.2400	26.5	0.2395	32.6

RESULTS

The results are summarized in Table I. The darters and sculpins were divided into size groups according to length-frequency distributions with modes at 21–22, 37–38 and 42–43 mm. (S.L.) for the darters and modes at 24–25, 40–41 and 60–61 mm. for the sculpins. These size groups are not directly comparable but the results indicate that such groupings are valid. The largest group of darters was set up since 84 percent of the individuals were males and displayed feeding characteristics which were not evident among the other groups. There were 72 and 25 empty stomachs among the sculpins and darters, respectively.

Several points become evident from examina-

tion of Table I. There is marked qualitative similarity in the feeding habits of the two species. Nineteen of the food items are common to both fish and make up the major portion of their diets. The remaining twelve items are not common to both and can be classed as incidental since they do not appear often nor do they contribute much in either numbers or weight. The major portion of the diet of both fishes is insectivorous. This substantiates the work of other investigators (Turner, 1921; Ricker, 1934; Koster, 1937; Dineen, 1951; and Bailey, 1952). Six of the food items listed are of the greatest importance to both species (Table I). These include *Stenonema* sp., *Arthroplea* sp. (*Ephemeroptera*), *Brachyptera* sp. (Plecoptera), *Psilotreta frontalis* (Trichoptera), Chironomidae and *Prosimulium hirtipes* (Diptera). They constitute 76 percent of the diet of both fishes by number and 72 percent and 56 percent by weight for the darter and sculpin, respectively.

There is considerable variation between intraspecific and interspecific size groups with respect to occurrence, numbers and weights of food items ingested. *Stenonema*, *Brachyptera*,

TABLE III

AVERAGE NUMBER AND WEIGHT OF EACH ORGANISM FOUND IN THE STOMACHS OF *ETHEOSTOMA F. FLABELLARE* AND *COTTUS B. BAIRDI* DURING THE FALL MONTHS, OCTOBER, NOVEMBER AND DECEMBER, 1951

Species	*Etheostoma f. flabellare*						*Cottus b. bairdi*					
Stomachs examined	19		41		7		37		54		4	
S.L. in mm	16–26		27–40		41–52		16–31		32–51		52–72	
Food item	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Ephemerida												
Stenonema sp.	.09	.60	.24	1.55	.56	3.60	.12	.80	.42	2.73	—	—
Arthroplea sp.	.04	.08	.29	.63	.47	1.03	.15	.33	.04	.07	—	—
Ephemera sp.	—	—	.03	.13	—	—	—	—	.01	.05	—	—
Isonychia sp.	.11	.60	.02	.13	.11	.60	—	—	.01	.05	—	—
Caenis sp.	—	—	—	—	—	—	—	—	.05	.05	—	—
Other	—	—	.01	—	—	—	—	—	—	—	—	—
Plecoptera												
Acroneuria lycorias	—	—	—	—	—	—	—	—	—	—	.17	3.79
Brachyptera sp.	.31	1.65	1.36	7.21	.20	1.05	.43	2.30	.55	2.93	—	—
Trichoptera												
Helicopsyche borealis	—	—	—	—	—	—	.03	.10	.02	.05	.17	.47
Psilotreta frontalis	.19	4.43	.14	3.40	—	—	.15	3.60	.44	10.45	1.50	36.00
Neophylax sp.	.04	.18	.24	1.20	.14	.70	.05	.27	.08	.39	—	—
Philopotamidae	.02	.08	.12	.60	—	—	—	—	—	—	—	—
Other	—	—	.01	.17	—	—	.03	.40	.09	1.03	—	—
Odonata												
Ophiogomphus sp.	—	—	—	—	—	—	—	—	.03	2.69	—	—
Diptera												
Chironomidae	2.81	1.11	2.69	1.07	.91	.37	.96	.40	1.24	.48	.17	.07
Dicranota currani	—	—	—	—	.11	3.98	—	—	.01	.35	—	—
Other	—	—	.02	—	—	—	—	—	—	—	—	—
Copepoda	1.95	—	.91	—	.22	—	.20	—	—	—	.33	—
Cladocera	1.33	—	.20	—	—	—	—	—	—	—	—	—
Amphipoda	.17	—	.19	—	—	—	.01	—	—	—	—	—
Isopoda	—	—	.01	—	—	—	—	—	—	—	—	—
Ostracoda	—	—	—	—	.06	—	—	—	—	—	—	—
Hydracnida	—	—	.08	—	—	—	—	—	—	—	—	—
Gastropoda	—	—	.01	—	—	—	—	—	—	—	—	—
Cottus b. bairdi	—	—	—	—	—	—	—	—	.01	—	—	—
Total	7.07	8.73	6.58	17.04	2.84	13.55	2.23	12.03	3.04	22.74	2.34	40.33

Chironomidae and Copepoda each had been consumed by at least 10 percent of the 16–26 mm. (S.L.) darters, and these four items comprised 77.9 percent of the stomach contents by number for the entire collection period. The 27–40 mm. darters consumed a greater variety of organisms. *Stenonema, Arthroplea, Brachyptera, Prosimulium* and the Chironomidae were represented in the stomachs of at least 10 percent of this group and made up 80.9 percent of the stomach contents by number during the entire period. *Stenonema, Arthroplea, Iron, Brachyptera, Isoperla, Prosimulium,* and the Chironomidae were consumed by at least 10 percent of the 41–52 mm. darters and they made up 84.3 percent of the stomach contents.

At least 10 percent of the 16–31 mm. sculpins fed on *Stenonema, Brachyptera* and the Chironomidae and these insects comprised 78.5 percent of the stomach contents by number for the entire collecting period. *Stenonema, Brachyptera, Psilotreta, Prosimulium* and the Chironomidae were in the stomachs of at least 10 percent of the 32–51 mm. group of sculpins and

TABLE IV

AVERAGE NUMBER AND WEIGHT OF EACH ORGANISM FOUND IN THE STOMACHS OF *ETHEOSTOMA F. FLABELLARE* AND *COTTUS B. BAIRDI* DURING THE WINTER MONTHS, JANUARY, FEBRUARY, AND MARCH, 1952

Species	*Etheostoma f. flabellare*						*Cottus b. bairdi*					
Stomachs examined	6		25		9		29		76		4	
S.L. in mm	16–26		27–40		41–52		16–31		32–51		52–72	
Food item	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Ephemerida												
Stenonema sp.	.17	1.08	—	—	.04	.26	.11	.68	.08	.50	—	—
Arthroplea sp.	—	—	.03	.07	.21	.47	—	—	.007	.02	—	—
Ephemera sp.	—	—	—	—	.08	.47	—	—	.02	.12	—	—
Isonychia sp.	—	—	.01	.08	—	—	—	—	.04	.23	—	—
Caenis sp.	—	—	—	—	—	—	—	—	.007	.007	—	—
Other	—	—	—	—	.08	.28	.02	.07	—	—	.17	.57
Plecoptera												
Acroneuria lycorias	—	—	—	—	—	—	—	—	.007	1.51	—	—
Brachyptera sp.	.09	.45	.99	5.25	.50	2.67	.20	1.08	.64	3.37	.17	.88
Trichoptera												
Helicopsyche borealis	—	—	—	—	—	—	—	—	.02	.05	.09	.23
Psilotreta frontalis	—	—	—	—	.04	1.00	—	—	.31	7.40	.09	2.00
Philopotamidae	—	—	.07	.33	—	—	.02	.10	.02	.10	—	—
Limnophilidae	—	—	—	—		—	—	—	.09	1.98	—	—
Other	—	—	.06	.67	.08	1.00	—	—	.06	.12	.17	—
Coleoptera												
Coptoptomus sp.	—	—	—	—	—	—	—	—	.007	.27	—	—
Psephenus lecontei	—	—	—	—	—	—	—	—	—	—	.17	1.30
Other	—	—	—	—	—	—	—	.78	.01	.28	.33	9.27
Diptera												
Chironomidae	.33	.13	2.05	.83	.67	.27	1.25	.43	3.20	.93	.67	.27
Prosimulium hirtipes	—	—	.03	.07	—	—	.06	.17	1.98	5.73	—	—
Other	—	—	—	—	—	—	—	—	.01	—	—	—
Insect remains	—	—	.18	1.83	.08	.85	.31	3.12	.10	1.00	—	—
Copepoda	.31	—	.03	—	—	—	—	—	.01	—	—	—
Cladocera	—	—	—	—	—	—	.02	—	—	—	—	—
Amphipoda	—	—	—	—	—	—	.02	—	—	—	—	—
Orconectes sp.	—	—	—	—	—	—	—	—	.01	—	—	—
Fish remains	—	—	—	—	—	—	—	—	—	—	.17	—
Total	.90	1.66	3.45	9.13	1.78	7.27	2.01	6.43	6.64	23.62	1.96	14.52

by number made up 87.2 percent of the stomach contents. *Stenonema*, *Acroneuria lycorias*, *Helicopsyche borealis*, *Psilotreta*, *Ophiogomphus* sp. and the Chironomidae were taken by at least 10 percent of the largest sculpins and made up 60.5 percent of their stomach contents.

Seasonal changes take place among the kinds and quantities of food items ingested for these two species. Table II presents the composition and quantity of the bottom fauna during the fall, winter, and spring months. There is a general decline in numbers and weight from the fall through the spring months. The total weight and number reflect this condition but it is somewhat obscured by the fact that certain species are increasing in number and weight as spring approaches. The numbers of the two mayflies, *Iron* and *Traulodes* and the stonefly *Isoperla* and the weight of the caddis flies, Limnophilidae, are examples of such exceptions to the general decline. Another exception is the build-up of the stonefly *Brachyptera* and the blackfly *Prosimulium hirtipes* during the winter months followed by a decline as spring approaches.

These seasonal changes in the bottom fauna

TABLE V

AVERAGE NUMBER AND WEIGHT OF EACH ORGANISM FOUND IN THE STOMACHS OF *ETHEOSTOMA F. FLABELLARE* AND *COTTUS B. BAIRDI* DURING THE SPRING MONTHS, APRIL AND MAY, 1952

Species	*Etheostoma f. flabellare*						*Cottus b. bairdi*					
Stomachs examined	10		94		29		48		45		10	
S.L. in mm	16–26		27–40		41–52		16–31		32–51		52–72	
Food item	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Ephemerida												
Stenonema sp.	—	—	.06	.40	.14	.93	.16	1.08	.11	.68	.13	.83
Arthroplea sp.	—	—	.14	.28	.13	.30	—	—	—	—	—	—
Ephemera sp.	—	—	.01	.05	—	—	—	—	—	—	—	—
Isonychia sp.	—	—	.18	.95	.11	.58	—	—	—	—	—	—
Caenis sp.	—	—	.17	.15	.03	.03	—	—	—	—	—	—
Iron sp.	—	—	.16	.73	.36	1.45	—	—	—	—	—	—
Other	.03	.85	.29	.98	.39	1.33	—	—	.02	.05	—	—
Plecoptera												
Acroneuria lycorias	—	—	—	—	—	—	—	—	—	—	.06	14.23
Isoperla sp.	.07	.30	.13	.53	.29	1.18	.20	.85	.78	3.18	—	—
Other	.61	2.50	.08	.33	.55	2.28	—	—	.03	.10	—	—
Trichoptera												
Psilotreta frontalis	—	—	.11	2.70	.07	1.43	.09	2.23	.33	7.85	.13	3.00
Neophylax sp.	—	—	.05	.23	—	—	—	—	—	—	—	—
Philopotamidae	—	—	.02	.08	—	—	.07	.35	.02	.08	—	—
Limnophilidae	—	—	.18	4.28	.15	3.50	—	—	.17	3.93	.06	1.48
Other	—	—	—	—	.03	.30	.11	1.33	.04	.43	—	—
Coleoptera												
Other	—	—	.03	.70	—	—	.04	1.18	.04	.10	—	—
Odonata												
Ophiogomphus sp.	—	—	—	—	—	—	.02	1.90	.01	.12	.19	17.78
Diptera												
Chironomidae	5.89	2.35	9.93	3.98	6.19	2.48	4.96	2.00	2.37	.95	.38	.25
Prosimulium hirtipes	.50	1.45	.42	1.20	5.00	14.50	—	—	.09	.25	.75	2.18
Insect remains	—	—	.63	6.45	.27	2.73	.30	3.10	.18	1.83	.19	1.93
Copepoda	—	—	.03	—	.03	—	—	—	—	—	—	—
Hydracnida	—	—	—	—	—	—	.02	—	—	—	—	—
Lamellibranchia	—	—	—	—	.03	—	—	—	—	—	—	—
Cottus b. bairdi	—	—	—	—	—	—	—	—	—	—	.25	—
Total	7.10	7.45	12.62	24.02	13.77	33.02	5.97	14.02	4.19	19.55	2.14	41.68

of the stream are also reflected in the stomach contents of both fishes. Five items are more important as food sources than is indicated in Table I. These are the mayfly *Iron*, the two stoneflies *Brachyptera* and *Isoperla*, the caddis flies Limnophilidae, and the blackfly *Prosimulium hirtipes* (Table III–V). The remaining items of significance in the diet of both fishes, the mayflies, *Stenonema* and *Arthroplea*, the caddis fly, *Psilotreta frontalis* and the midges, Chironomidae, do not show any marked seasonal changes. They were present throughout the period and were ingested by both fishes.

Discussion

Fishery investigators, making an examination of the food habits of two or more species of fish in the same habitat, state that these species are in competition if the same food organisms are common to the diet of both (see references in introduction). This may imply that there is not enough food to go around and competition results when there is a common demand exceeding a limited supply. Hartley (1948) noted that there is general competition between all fish in a community for certain food items but that there is no complete identity of food habits between any two species. Lagler (1944) has commented that similarity of food habits within the same community cannot alone suffice to demonstrate competition. Also, Lagler (1944) and Hartley (1948) have pointed out, in the absence of measurements of the density of food organisms in the natural habitat and the proportion removed by predation, competition can only mean taking an appreciable proportion of a common food, without implying that the food supply is limited. The proportion removed by predation can be assessed only after determining the sizes of the predator and prey populations, the size of the daily food ration and the rates at which the various food items are utilized and digested. Only then can the degree of competition be ascertained.

The two species of fish under examination appear to occupy the same food niche, judging from the stomach examinations. This suggests they have certain ecological requirements in common but, as Hairston (1951) noted, a common need does not create competition.

A reduction in competition can be accomplished by a factor or group of factors that keep the ratio low between the population and the environmental resources. These factors are the organism itself, the physical environment and the biological environment (Crombie, 1947). Allee, *et al.*, (1949: 518) point out that since different species have different heredities, ecologically similar species will have different requirements within the same food niche.

The availability of the various food items will largely determine the diet of a species. Diet is influenced by the distribution and behavior of the food item and also the behavior and morphology of the predator. At times, however, it is apparent that selection for certain available food items is exercised by a predator species; differences in selectivity would further tend to reduce competition.

The reduced temperatures in the stream environment during the period of study have a direct influence on the metabolism of the fish present. The demands on the food supply will not be maximal at such times, as indicated in Tables III–V. Such a condition can reduce or even eliminate any competition between two species even though the diet remains qualitatively the same.

The presence of the mayfly, *Stenonema*, is remarkably consistent in regard to the number of fishes having eaten it, indicating that it is available to all sizes of both fish species. Bailey (1952) reported that the mayflies as a group are an important food for the sculpin because of their regular occurrence and size even though they comprise a low percentage of the total number. When the average numbers and weights of *Stenonema* are considered, it becomes apparent that the number consumed by the darter increases with an increase in the size of the fish. This is even more true for the sculpin through the intermediate sizes but there is a sharp decline for the largest fishes. The results for *Arthroplea* are somewhat different. As the size of the darter increases, more fish consume greater numbers of this mayfly; however, the converse is true for the sculpin. It is evident that *Arthroplea* is disproportionately more important in the diet of the darter than it is for the sculpin. This suggests a selective behavior on the part of the darters with regard to *Arthroplea*. *Stenonema* appears to have been

taken more at random by both the darter and the sculpin.

The stonefly, *Brachyptera*, is an important item in the diet of both fishes; however, Table I does indicate that fewer numbers of fish ingest it as they increase in size with the exception of the 32–51 mm. group of sculpins. Table I shows an increase in numbers consumed from the small fish to the median group with a subsequent decline for the largest fishes. *Brachyptera* is a cold water, winter form that does not start development until there is a decline in water temperature. It first appeared in the bottom samples and stomachs on October 12, and was last seen in the March 28 collection. With this in mind, Tables III–V present a truer picture of the importance of this organism. A relatively high percentage of the darters had ingested the stonefly and it appears to be more important for the intermediate size group of fish.

As water temperatures rose, *Isoperla*, another stonefly of comparable size, began to replace the declining numbers of *Brachyptera*. In general, as the darters increase in size they tend to take an increased number of *Isoperla*; however, this organism is of little numerical importance, comprising only 1, 1 and 2 percent of the stomach contents. It is slightly more important to the sculpin making up 3.4 percent of the food of the small group and 18.6 percent of the food of the 32–51 mm. fish. Therefore, even though *Isoperla* replaced *Brachyptera* in the diet of both fishes, it does not have the same importance as a food item.

The caddis fly, *Psilotreta*, is of greater importance to the sculpin than to the darter and selectivity is evident. The larva builds a tubular case of sand grains, the whole cemented in a vertical position on the upstream edge of flat stones prior to pupation. The barred fantail darter is a slender fish with a small mouth gape. The sculpin is a heavy-bodied, muscular fish with a large mouth opening. The average ratios between standard length and mouth gape were 0.092 and 0.153 for the darter and sculpin, respectively. Consequently, the sculpin has a mouth opening 1.7 times as large as that of the darter and can, for the same length fish, ingest an organism much larger than can the darter. Northcote (1954) noted this same condition among the sculpins *C. rotheus* and *C. asper*. This fact, coupled with the heavier jaws and more muscular body of the sculpin, can explain the results obtained for *Psilotreta* in Tables I, III, IV and V. Relatively few of the darters and only an occasional small sculpin had fed on this caddis fly. In addition, the few which did contain *Psilotreta* in the stomachs had ingested only small numbers. It is not until the median and large size sculpins that this caddis fly becomes important. An increase in the size of the sculpin is paralleled by a corresponding increase in the number of larvae consumed. An interesting relationship between the caddis fly and the two fish species is observed in the fact that the sculpins had, for the most part, ingested the sand cases with the larvae in them while the darters did not. Apparently the sculpins ingested case and insect as the latter moved about or tore the cases from their places of attachment while the darters fed on the caddis flies when the latter were out of their cases.

The Chironomidae make up an important basic item in the diet of both fishes (Tables I, III, IV and V). However, their importance does decrease with an increase in fish size. This is more evident for the sculpins than the darters. Both species of fish fed heavily on the midges since they were the most abundant single component of the bottom fauna, composing 40 percent of the total. Selectivity does not appear to be evident.

Table IV demonstrates the value of *Prosimulium* in the diet of both fishes. This black fly did not appear in the bottom fauna or stomachs until the February 29 collection. It is of greater importance to the darter as indicated by the frequency with which it was ingested as well as the number per fish, especially for the largest size group. It is of considerable importance to the 32–51 mm. group of sculpins but less significant for the other two sizes.

The Copepoda are important in the diet of the smallest darters but the frequency of appearance and the numbers ingested declines markedly as the fish matures. As Ricker (1934) pointed out, they are of minor importance to the sculpin.

The remaining mayflies, other than *Stenonema* and *Arthroplea*, are of minor importance (see Tables III–V). *Ephemera* and *Caenis* are burrowing forms and are relatively unavailable. *Isonychia* was not abundant in the habitat.

Iron did not appear until April 18 and was of little importance to any except the largest darters (see Table V). The stonefly, *Acroneuria lycorias*, was not abundant and, when present, was available only to the larger sculpins because of size. The caddis fly, *Helicopsyche borealis*, was available only to the sculpin because it fastened its cases to stones. *Neophylax* and the Philopotamidae were locally abundant only in the fast flowing riffles, living in between the rocks where they built their net cases. There were few Limnophilidae and they were, for the most part, too large to be ingested. The Coleoptera were not abundant and were generally unavailable because of their large size. The smaller individuals of the dragon fly, *Ophiogomphus*, were available only to the larger sculpins. The Diptera, other than the midges and blackfly, were generally too large to be ingested. These and the remaining items can be called incidental, since they appear so seldom.

The total average number and weight per stomach bring out two facts. The darters consume a greater average number of organisms than do the sculpins. This suggests that the darter is much more active in looking for food and has a correspondingly high feeding rate. Field and laboratory observations have shown darters to be frequently on the move, poking about among the rocks and often ingesting organisms. The sculpin is much more sedentary in its habits. Secondly, even though the number per stomach did not vary to any great extent from one size group to the next, there was an increase in weight. On the average, as the fishes increase in size, they ingest increasingly larger organisms. This is not only apparent between the size groups of each species but even more pronounced when the darters and sculpins are compared. This effect of particle size on the availability of food organisms is particularly well illustrated by the caddis flies, *Psilotreta* and *Helicopsyche*.

Relatively few species make up the major portion of each fish's diet. There is an increase in the numbers of species ingested from the smallest to the intermediate size groups of both fishes and a decline for the largest size groups. This decline is accompanied by an increase in the size of the organisms consumed.

Summary

A food habit study was conducted on 240 barred fantail darters, *Etheostoma f. flabellare*, and 307 northern mottled sculpins, *Cottus b. bairdi*. The fish were collected from a small headwater stream in Allegany County, New York, from October 12, 1951 to May 9, 1952.

There is great qualitative similarity in the food habits of both fishes. However, there is a shift in importance for the various food items among different size groups within the same species and between the two species.

The qualitative similarity in food habits between the two species might suggest competition. If competition for food exists between these two fishes, it is kept at a low level by the low metabolic demands of both species during the period studied. Differences in feeding behavior, availability and the exercise of selectivity for certain food items also tend to reduce competition.

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Sequential Analysis in Fishery Research

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INTRODUCTION

IN PLANNING controlled experiments, a stage is always reached at which some judgment must be made about the size of the sample—that is, the number of observations or measurements required to make a decision with specified limits of error. Too large a sample implies a waste of time, money and effort; too small a sample diminishes the utility of the results. Methods which reduce the cost and time required to reach decisions are of general interest to research workers. One such method which appears to have found little application in fishery research is sequential analysis. The objective of this paper is to arouse interest in the potential utility of this technique in certain types of fishery problems.

Sequential analysis is essentially a procedure which leads to a decision without fixing the sample size in advance. The probabilities associated with the particular order of occurrence of the items so far observed are used to formulate rules which result in a reduction in the average sample number required for a decision. The basic theory and certain applications to the field of industrial acceptance sampling have been developed by Wald and his associates (Statistical Research Group, Columbia University, 1945; Wald, 1947). These workers were well aware of the possibilities of the method in experimental work.

A hypothetical application will be treated here to outline the essential elements of the method.

AN APPLICATION

A research facility has been constructed at Bonneville Dam on the Columbia River by the Corps of Engineers of the U. S. Army. The U. S. Fish and Wildlife Service has been designated the primary research agency in a program designed to solve important biological problems associated with fishways. Two of the most urgent problems are: (1) to determine the fishway entrance conditions most attractive to migrating adult salmonoids, and (2) to establish the conditions within a fishway which result in a maximum rate of movement.

Application of the results of this research, and thus the selection of the treatments to be tested, will be limited by practical engineering and cost considerations. Within these limitations, the flexibility of the experimental structure will permit a reasonably wide range of treatment combinations to be tested. Emphasis will be on the importance of differences between levels of relatively few variables—those important to fishway construction—rather than

on a large number of more elusive factors which might possibly influence a choice.

The experimental technique for attacking the first problem above will be to subject successive individuals or small groups of fish to choices. One such pair of entrance conditions will be submerged and surface attraction flows. The proportions entering the fishway by each route will measure the effectiveness of the two flows.

Prior to the exploratory experiments common to all new research, preliminary decisions must be made about (1) the minimum important difference between the submerged and surface flows, and (2) the consequences, and therefore the risks, of the α (Type I) and β (Type 2) errors on the initial hypothesis of no difference in effect. These are difficult questions. There are two reasons for specifying reasonably large differences whether or not sequential plans are adopted. Excessive sampling would be needed to detect small differences, and only relatively large differences will be of practical importance. The risks of making wrong decisions should be governed by the consequences; these are often difficult to anticipate in experimental work. Here, an α error would wrongly lead to the conclusion that one condition was better, while a β error would result in the false statement that both were the same. Since a β error would lead to overlooking an effective condition, it would be safer to make the risk of this error smaller. An α error would result in further research on an ineffective condition, but this would soon be discovered.

For this illustration the hypothesis that fifty percent of the fish are attracted to the submerged flow will be tested against the alternative that sixty five percent of the fish are so attracted. The risk of saying that the submerged flow is more attractive when the effects of the two flows are equal will be controlled at $\alpha = .05$. The chance of concluding that the flows are equally attractive when at least sixty percent of the fish enter by the submerged flow will be specified as $\beta = .01$.

The characterization of the sequential procedure will parallel the notation employed by Dixon and Massey (1951):

H_0 = the test hypothesis that .50 of the fish go to the submerged flow.

H_1 = the alternative hypothesis that .65 of the fish go to the submerged flow.

p = the true proportion entering the submerged flow.

p_0 = the proportion specified in the test hypothesis (.50).

p_1 = the proportion specified in the alternative (.65).

p_{0m} = the probability that the choices of the m fish so far observed would occur if H_0 were true.

p_{1m} = the probability that the choices of the m fish so far observed would occur if H_1 were true.

l_m = the number of fish that go to the submerged flow out of the first m fish.

u_m = the number of fish that go to the surface flow out of the first m fish.

After each fish has entered, one of three decision rules will be applied:

(1) If $\frac{p_{1m}}{p_{0m}} \leq \frac{\beta}{1-\alpha}$, accept H_0.

(2) If $\frac{p_{1m}}{p_{0m}} \geq \frac{1-\beta}{\alpha}$, accept H_1.

(3) If $\frac{\beta}{1-\alpha} < \frac{p_{1m}}{p_{0m}} < \frac{1-\beta}{\alpha}$, continue sampling.

The reader is referred to Wald (*loc. cit.*) for the formulation of these rules and of the equations appearing later in the text.

For any sequential sampling plan determined by α, β, p_0 and p_1, the rules may be visualized by constructing parallel lines from Equations (1) and (2) below. Natural logarithms are used, and the result is a convenient way of simultaneously recording data and testing hypotheses:

$$l_m \log \frac{p_1}{p_0} + u_m \log \frac{1-p_1}{1-p_0} = \log \frac{1-\beta}{\alpha} \quad \text{(Equation 1)}$$

$$l_m \log \frac{p_1}{p_0} + u_m \log \frac{1-p_1}{1-p_0} = \log \frac{\beta}{1-\alpha} \quad \text{(Equation 2)}$$

These equations define the boundaries of the critical regions. After simplifying and taking natural logarithms with $\alpha = .05$, $\beta = .01$,

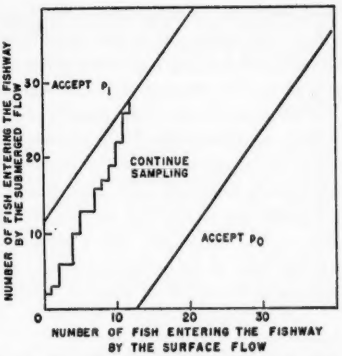

FIG. 1. Results of recording hypothetical data in the text to reach a decision with the sequential sampling plan determined by $\alpha = .05$, $\beta = .01$, $p_0 = .50$ and $p_1 = .65$.

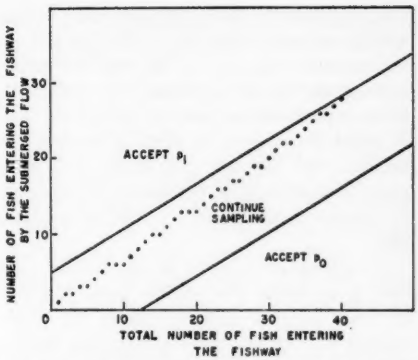

FIG. 2. Results of recording hypothetical data by the second method described in the text.

$p_0 = .50$ and $p_1 = .65$, Equations (1) and (2) reduce to Equations (3) and (4), respectively:

$$.262\, l_m - .357\, u_m = 2.986 \quad \text{(Equation 3)}$$

$$.262\, l_m - .357\, u_m = -4.554 \quad \text{(Equation 4)}$$

These two lines with a common slope are shown in Figure 1, on which the data may be recorded. A line is drawn one unit up if a fish goes to the submerged flow and one unit to the right if a fish goes to the surface flow. When either control line is reached or crossed, the indicated decision is reached.

Suppose that the first forty fish entered the experimental fishway in this sequence: *l l u l u l l l u u l l l l l u l l l u u l l l u l l l u l l l u l l l u l l l l u l l*. Sampling could be terminated with the decision that at least sixty-five percent of the fish are attracted to the submerged flow. A more reliable estimate of p could of course be obtained with a larger sample. At this stage it would be more important to know as quickly as possible if the sixty-five percent–thirty-five percent division (or greater) occurred, since (for this illustration) any smaller difference would be unimportant. Plotting the data as in Figure 1 also visualizes the random variation, assuming that conditions remain uniform for the duration of the experiment. It should not be undertaken sequentially, otherwise.

If the decision to continue sampling recurs even after a rather large sample, this indicates either that $p_0 < p < p_1$, or that α and β are too small.

Quite objective preliminary decisions may be made about sample size. It is reasonable that if $p_0 < p < p_1$, a larger sample would be needed than if $p < p_0$ or if $p > p_1$. The average sample number if $p = p_0$, designated $\bar{n}_{p_0}$, and if $p = p_1$, designated $\bar{n}_{p_1}$, are of most interest. Formulas for these quantities are:

$$\frac{(1-\alpha)\log\dfrac{\beta}{1-\alpha} + \alpha\log\dfrac{1-\beta}{\alpha}}{p_0\log\dfrac{p_1}{p_0} + (1-p_0)\log\dfrac{(1-p_1)}{(1-p_0)}} = \bar{n}_{p_0} \quad \text{(Equation 5)}$$

$$\frac{\beta\log\dfrac{\beta}{1-\alpha} + (1-\beta)\log\dfrac{1-\beta}{\alpha}}{p_1\log\dfrac{p_1}{p_0} + (1-p_1)\log\dfrac{(1-p_1)}{(1-p_0)}} = \bar{n}_{p_1} \quad \text{(Equation 6)}$$

Most of the above quantities will be available from previous computations to determine the lines. For this example, $\bar{n}_{p_0} = 88$, and $\bar{n}_{p_1} = 65$. The larger of these quantities is designated $\bar{n}$.

The sample size required for a decision will not exceed 3 $\bar{n}$ for practical purposes. Unless $p_0 < p < p_1$, the number required will more often than not be less than $\bar{n}$, as in this example. The quantities $\bar{n}_{p_0}$ and $\bar{n}_{p_1}$ can be used to decide in advance whether or not the chosen α, β, p_0 and p_1 lead to excessive sampling. If so, the specified difference between p_0 and p_1 should be increased and/or the risk of being wrong should be increased.

There is no guarantee that a particular pair of hypotheses will not require exhaustive sampling, regardless of where true p may lie. The

computed average sample number refers to the average amount of sampling in the long run.

The reader will find in the last two references procedures for terminating an experiment before a particular sample size is reached. This is called truncation; its effect is to reach a decision with increased risk levels. It is suggested that truncation procedures be explored by workers interested in a particular application.

An alternative method of determining the lines is available. The number possessing the attribute may be plotted against the total number of observations. The equations of the upper and lower lines, respectively, may be written $l_2 = h_2 + sn$ and $l_1 = -h_1 + sn$, where l is the number entering the submerged flow, s is the common slope, n is the total number of fish entering the experimental fishway, and h_2 and h_1 are the intercepts. The slope is always between p_0 and p_1. The intercepts and the slope are given by:

$$\frac{\log \frac{1-\alpha}{\beta}}{\log \frac{p_1}{p_0}\left(\frac{1-p_0}{1-p_1}\right)} = h_1 \qquad \text{(Equation 7)}$$

$$\frac{\log \frac{1-\beta}{\alpha}}{\log \frac{p_1}{p_0}\left(\frac{1-p_0}{1-p_1}\right)} = h_2 \qquad \text{(Equation 8)}$$

$$\frac{\log \frac{1-p_0}{1-p_1}}{\log \frac{p_1}{p_0}\left(\frac{1-p_0}{1-p_1}\right)} = s \qquad \text{(Equation 9)}$$

From these equations the upper and lower lines, respectively, now become $l_2 = 4.82 + .58n$ and $l_1 = -7.35 + 58n$. These lines are shown in Figure 2 with the same data recorded. The decision to accept H_1 again occurs after these forty observations.

The assumption is made that the choice of each fish is independent, in the sense that the chance of a fish making a given response is not influenced by the response made by any other fish. With individuals, this usually may be controlled experimentally. With groups, it will generally be an unrealistic assumption. If preliminary work validates this assumption with groups, each fish of a group will contribute a separate point on graphs like Figure 1 and Figure 2 as soon as its response is made. If the assumption is not valid, as when schooling behavior occurs, each group will contribute only one point on the graph.

Care should then be taken to use groups of equal size in testing a particular pair of hypotheses, unless it is precisely known within what limits of group sizes a response is uniform. In some cases it may be easier to test groups than individuals; often it will be more realistic to do so.

Acknowledgements

The author is indebted to Charles O. Junge, Jr. of the State of Washington Department of Fisheries for helpful suggestions, and to T. M. Widrig, R. A. Fredin and D. D. Worlund of the U. S. Fish and Wildlife Service for review of the manuscript.

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Concretions of the Alewife, *Pomolobus pseudoharengus* (Wilson), at Onondaga Lake, New York

WILFORD A. DENCE

THE alewife represents one of the few marine fishes that has successfully adapted itself to freshwater environments. The distribution pattern of this species in fresh water, however, is extremely diverse and unpredictable. One may find it abundantly in certain inland lakes while other waters that appear equally suitable either contain a few individuals or none. Onondaga Lake is one of the few places in central New York in which the species seems to occur in abundance. It would be unwise even to hazard a guess as to the probable date on which alewives first became established in the lake. As a matter of fact, their presence could be overlooked by the average layman were it not for the numerous "concretions" that are deposited on the beaches. So far as the writer knows, there are no published records of this species for Onondaga Lake. However, no exhaustive studies have been conducted there in recent years, and it may not have been present in earlier times when fishermen frequented the lake in quest of whitefish and other desirable species that abounded there.

This lack of data on alewives at Onondaga Lake is not surprising, because there is no accurate information on the date, place or manner of establishment of this fish in any of the inland fresh waters of New York. The species has been known to inhabit Lake Ontario in immense numbers for at least a century, and the general opinion is that it appeared there long before it reached other places in the State. The generally accepted theory to explain its presence in Lake Ontario (see Pritchard, 1929) is that it was "supposed to have been introduced through error when the intention was to introduce shad." There are no reliable records to support the contention that alewives may have reached the lake by migrating up the St. Lawrence River. The species customarily invades coastal waters to spawn, and, while it is entirely possible, one ordinarily would not expect it to travel inland as far as Lake Ontario. Its occurrence in waters of central New York, including Onondaga Lake, may be due to migration from Lake Ontario or to direct stocking. There is no factual basis for either theory.

The manner in which great numbers reached Seneca, Cayuga and Keuka Lakes of the Finger Lake series also is a mystery. Bean (1902) wrote that "It is thought to have been introduced into the lakes of Central New York by the State Fish Commission." There are, however, no available records of such plantings. As was the case at Lake Ontario, the general belief is that the introduction into the Finger Lakes was accidental. Greeley (1928: 44), in discussing the extreme abundance of alewives in the Finger Lakes, said that "We believe they entered by means of the canal system which formerly extended to Keuka Lake and still enters Cayuga and Seneca.... They are evidently not the remnant of postglacial invasion from the sea, nor migrants by way of the Oswego River before the dams were constructed, for they certainly should have entered Canandaigua and Owasco Lakes with equal ease."

Adams and Hankinson (1928) reported only one specimen in their extensive collections at Oneida Lake, and they were of the opinion that the species migrated there from Lake Ontario through the Oswego River. So far as is known, no additional specimens have been reported for the lake.

In reporting on the fishes of the Oswego watershed of New York Greeley (1928) mentioned that "specimens were taken in the Oswego River at Three Rivers Point." No mention, however, was made of the occurrence elsewhere in the watershed except, as noted above, in the Finger Lakes. The outlet of Onondaga Lake extends about six miles before joining other rivers at Three Rivers Point. The writer found a single dead specimen in the Seneca River system at Cross Lake in 1931.

Even though the records show that alewives are rather sporadic in distribution in central New York, there are indications that they may exist in many waters where they have never been observed or collected. Since the alewife is not a game fish and is rarely if ever taken on

the hook, its presence in some instances may be unsuspected. Where it occurs in great numbers, as it often does when once established, its presence may be manifested by high mortality. Frequently its occurrence in certain waters is not suspected until carcasses or, in this particular instance, concretions are found on the shores. Such has been the case at Onondaga Lake and certain other lakes of the area. So far as is known the species heretofore has never been reported in the form of concretions.

Onondaga Lake is five miles long, one mile wide, and has a maximum depth of 60 feet. It is northwest of, and partly surrounded by, the city of Syracuse. The lake has been heavily impregnated with industrial waste and domestic sewage for many years and is consequently unsuitable for whitefish and trout that once abounded there. The south shore of the lake has great piles of soda ash from an industrial plant. The adjacent areas on the north shore yielded 12,000,000 tons of salt from 1797 to 1904. A small amount of brackish water still enters the lake through seepage. Undoubtedly a great amount of salt solution likewise enters the lake as a result of the thousands of tons of salt that are used on the streets of Syracuse throughout the winter. As much as 500 tons sometimes are used in a single treatment. The existing species of fish, of which carp is the most conspicuous due to its size and abundance, are worthless for human consumption because the flesh has a peculiar flavor resembling tar.

Thousands of alewife concretions have been observed on the beaches of Onondaga Lake in recent years, and the fact that they are continually being deposited there is indicative of their great abundance. Unless the initial stock of alewives was established in the lake many years ago there is no reason to suspect that the species was introduced intentionally. This lake has been used very little for angling purposes in recent years because of its polluted condition, so that there has been no current stocking program for it. In this particular instance it seems more plausible that the alewives became established through migration from adjacent inland waters.

The great mortality of this species in freshwater environments is not unusual. It is particularly conspicuous at Lake Ontario where tons of dead alewives of various sizes are washed onto the beaches annually, thus creating a health menace and an unsightly appearance to campers and bathers. Many of the carcasses mummify and persist in this state for months. The reason for this great mortality has never been determined. Those who have examined dead and dying fish find no serious pathological factors of endemic proportions, and the specimens are relatively free of parasites. Most investigators attribute the losses to the fact that the species is out of its natural environment and that the newly acquired habitat falls short of providing the essential requirements for a normal existence.

The alewives at Onondaga Lake, unlike those at Lake Ontario, have never been found on the beaches except as concretions. Although fairly numerous these concretions generally are overlooked, particularly by the public, because the head, most of the fins and scales of the alewife are missing (Pl. I). They can be easily recognized and identified by biologists, however, because the scutes along the ventral ridge usually are intact and often some of the scales, ribs and portions of the pelvic fins as well. The muscle fibers have been completely transformed into the white chalky substance of the concretion, leaving the bones, integument, scutes, gut and other resistant parts to maintain the form.

The gizzard shad (*Dorosoma cepedianum*) is the only other species inhabiting the lake that might be confused with the alewife. It has become rather abundant in the lake and throughout the watershed, particularly during the past two years. Since it has a longer anal fin and consequently fewer scutes than an alewife it can be readily distinguished even in concretions. Furthermore, the scutes of the gizzard shad are somewhat heavier and blunter. Fresh or dried carcasses of gizzard shad were first collected on the beaches during the summer of 1953. While some of the concretions superficially suggested gizzard shad, because of their size, only three specimens could be definitely identified as belonging to that species.

Most of the specimens erode to the extent that less than one-half of the original form exists. The ventral side, being fortified with the ridge of scutes, generally resists erosion more than the dorsal portion. In fact the vertebral column and all of the tissues adjacent to it in

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Typical alewife concretions from Onondaga Lake. The pelvic fins may be seen on some of the specimens.

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most cases are missing. Likewise the anterior part of the fish including the head and, generally, a portion of the trunk, as well, are always lacking, as is all of that portion posterior to and including the caudal peduncle. The coelomic cavity in most instances is only partially filled with the substance of the concretion. Frequently the posterior end of the gut is in place and not disintegrated, appearing as a leather-like tube uncollapsed and not filled with deposited material. Cross sections through the trunk region of some specimens reveal that the limits of the integument could be differentiated from the region formerly occupied with muscle tissue by the color and texture. This outer region is a homogeneous pale yellowish mass much firmer in texture than the adjacent material. It closely resembles candle wax in feel and texture.

A study of numerous concretions in the laboratory indicated that the transformation must have been rather rapid, otherwise the form as well as the scales and bones would not have been *in situ* and so well preserved. It is suspected that the high oil content of the flesh of this species retarded decomposition considerably. Some of the concretions still had a decided yellow color and were pastelike in texture. Evidently the oil had not been completely oxidized in these specimens. Furthermore, a peculiar rancid odor was apparent on all the concretions, but particularly on the unbleached ones.

Chemical analyses of typical selected concretions revealed that about 90 percent of the contents was organic, the balance principally calcium. Dry specimens could be easily ignited and the flame would persist until all the organic matter was consumed. The bony tissue, being less inflammable than the surrounding substance, usually smoldered and thus generated disagreeable odors.

One can only speculate as to the time, place and manner in which alewives changed from the living to the concretion form. The fact that dead alewives in the flesh are not found in shallow water or on the beaches indicates that the carcasses remain below the lake surface, possibly on the lake bottom, where they are transformed into concretions. It is to be assumed that metamorphosis begins immediately and progresses with sufficient rapidity to preserve the shape and to prevent the more resistant parts from becoming disarticulated.

Judging from observations in other areas, such as Lake Ontario, decomposition normally is much slower for the alewife than it is with most other fish species. Perhaps this may be attributed to the more oily nature of its flesh as compared with associated species.

The deposition of concretions on the beaches occurs mostly during late summer and autumn, although some are found at other times. This is to be expected because mortality normally is greatest during the spawning season, which occurs in the spring. Very few are found during the winter even when the lake is unfrozen. Since the prevailing winds are from the west, most of the specimens are left on the east shore. Deposition on the beaches is dependent on wave action. The writer has never seen concretions suspended in the water or in the process of deposition. Since the specific gravity of specimens taken at the water's edge, and therefore in a wet condition, is much less than water, it is assumed that they were suspended in water at the time of deposition. The question arises as to whether the specimens maintained a low specific gravity from the time of death or gradually acquired that condition during the formation of the concretion.

It is difficult to understand why the dying or recently dead alewives of Onondaga Lake do not float shoreward as do those of Lake Ontario. Certain other fish species, particularly carp, commonly are found on the beaches on Onondaga Lake but show no evidence of conversion into concretions; they either decompose or are consumed by scavengers. Portions of at least two gizzard shad concretions were collected at the lake during the summer of 1954, but specimens in the flesh, including both fresh and mummified, likewise were observed. Furthermore, occasional concretions have been collected in which the bones of a chicken or a duck served as the supporting structure. In specimens of this sort the material was similar in appearance, and could be ignited, as with the alewife concretions.

Another type of concretion, not to be confused with the above, occurred in extensive amounts along the beaches. These, however, were inorganic, gravel-like in appearance, fairly soft, and of a fine granular composition mostly

of about pea size. The material in these concretions may have originated from the waste materials of the nearby Solvay Process plant.

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Movement of Fish under the Ice

John Greenbank

COMPARATIVELY little is known about the movement of fish in ice-covered lakes. Direct observation usually is impossible, and fish trapping under the ice is cumbersome and arduous.

The Upper Mississippi River Conservation Committee, in the period 1945–48, conducted extensive investigations of the winter drawdown of navigation pools of the Mississippi River between Hastings, Minnesota, and St. Louis, Missouri. As a part of these studies, a trap-netting experiment was performed in Target Lake, near La Crosse, Wisconsin, in the winter 1946–47.

Target Lake is a back water, lying close to the main channel of the river, with an area of about 150 acres. It is uniformly shallow, having a maximum depth of about eight feet. It is fed by a small inlet stream. An outlet, about 200 feet wide and only a few hundred feet in length, connects the lake with a large side channel of the river. The depth in most places in the outlet is less than four feet.

The experiment was started on January 9, 1947, and concluded on February 20. Two trap nets of 1¼-inch bar mesh, with three-foot by six-foot frames, were set in the outlet channel at its narrowest point. The nets were placed facing in opposite directions, so that they trapped fish either entering or leaving the lake. Webbing was strung across the channel, forming a complete barricade, and serving to guide the fish into the nets. Through an error, the two nets were not duplicates in construction and mesh size.

The nets were examined daily, during the forenoon, except for the days of January 30 and February 4, when it was impossible to get to them. The fish were identified, counted, and returned to the water beyond the net in which they were caught, so that they could continue in the direction in which they supposedly had been moving when captured. No record was kept of the size of the fish. There was a representation of various sizes for each species, except for the fish which were small enough to escape from a net of this size mesh.

During the period from January 13 to February 16, all fish caught were marked before being returned to the water, by clipping fins in such a manner that the fish could be identified, if recaptured, with the net in which they were caught first.

The water level and the depth of snow on the ice near the nets were measured daily. Determination of dissolved oxygen in the water was made at two or three-day intervals.

During the 40 days of the experiment, a total of 3,328 fish were taken in the two nets (Table I). Over 80 percent of these consisted of three species, black crappie (*Pomoxis nigromaculatus*), yellow bullhead (*Ameiurus natalis*), and bowfin (*Amia calva*). Twenty other species were captured, in various numbers.

Consistently, a larger number of fish were taken in the net arranged to trap fish entering

TABLE I

INCHES OF SNOW COVER ON THE ICE AND NUMBERS OF FISH CAPTURED IN NETS

Date, Jan–Feb. 1947	Snow on ice, inches	Fish entering the lake					Fish leaving the lake					Total fish, both nets
		Black crappie	Yell. bullhead	Bowfin	Other	Total	Black crappie	Yell. bullhead	Bowfin	Other	Total	
10	2	44	28	14	8	94	11	3	1	19	34	128
11	1½	96	14	13	5	128	17	11	1	5	34	162
12	1½	45	6	39	9	99	2	0	9	6	17	116
13	1½	23	5	61	13	102	8	4	15	6	33	135
14	0	17	9	24	4	54	1	0	6	5	12	66
15	0	1	1	2	6	10	0	0	0	1	1	11
16	½	3	0	0	2	5	0	0	0	0	0	5
17	½	2	1	8	6	17	1	0	0	2	3	20
18	½	3	0	2	5	10	1	0	2	2	5	15
19	½	2	0	6	7	15	0	0	0	6	6	21
20	½	4	2	1	3	10	1	0	0	4	5	15
21	½	2	1	2	0	5	0	0	0	1	1	6
22	½	2	1	12	5	20	0	0	1	3	4	24
23	½	3	0	15	3	21	0	0	4	0	4	25
24	0	4	2	9	4	19	6	0	1	4	11	30
25	0	12	0	0	3	15	3	0	0	7	10	25
26	0	0	0	0	3	3	0	0	0	2	2	5
27	0	0	0	0	4	4	0	1	0	3	4	8
28	0	0	3	0	1	4	0	0	0	0	0	4
29	7	1	1	0	5	7	0	0	0	2	2	9
30		(Missing)					(Missing)					
31	10	0	0	2	1	3	0	1	0	1	2	5
1	10	0	1	4	7	12	1	0	0	1	2	14
2	10	0	19	12	11	42	0	2	0	1	3	45
3	10	5	62	32	19	118	1	6	6	5	18	136
4		(Missing)					(Missing)					
5	10	5	25	42	4	76	7	11	12	4	34	110
6	10	117	13	13	15	158	75	11	6	34	126	284
7	10	182	46	22	36	286	128	33	22	55	238	524
8	8	115	64	58	15	252	61	27	23	29	140	392
9	8	21	47	78	11	157	26	21	30	13	90	247
10	8	40	33	34	6	113	35	19	24	10	88	201
11	6	23	16	31	10	80	14	27	15	5	61	141
12	6	7	14	10	6	37	10	18	3	5	36	73
13	4	13	22	31	4	70	30	44	20	6	100	170
14	0	34	9	22	9	74	2	20	2	3	27	101
15	0	1	2	1	9	13	2	0	1	2	5	18
16	0	0	1	3	2	6	1	0	0	1	2	8
17	0	0	1	0	2	3	0	0	0	1	1	4
18	0	0	0	0	0	0	0	1	0	2	3	3
19	0	1	1	1	1	4	0	2	1	1	4	8
20	0	0	2	1	2	5	2	3	1	3	9	14
Totals.....		828	452	605	266	2151	446	265	206	260	1177	3328

the lake, than in the other net. The difference may have been due to the variation in construction of the two nets. The species percentage composition was roughly the same for each net.

Although the movement of fish occurred in both directions in the outlet channel, it cannot be considered a Brownian type of movement. The fish were not simply milling about in the

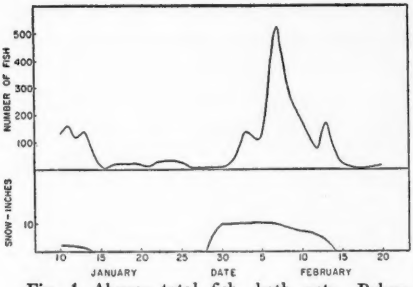

Fig. 1. Above: total fish, both nets. Below: amount of snow on the ice.

vicinity of the nets. They definitely were on their way, in one direction or the other. The number of marked fish recaptured was very small. Once a fish passed beyond a net, it kept on going.

The nets gave no indication of the depth level at which the fish were swimming when they encountered the net opening or the web lead, and hence did not show vertical movements. But since the lake and the outlet channel were shallow, compared to their area, the movement almost may be said to have been in a two-dimensional plane. Within this plane, movement in the lake may have been taking place in a number of directions, perhaps completely at random.[1] However, once the fish entered the constricted channel in which the nets were set, their movement was funneled and became, in effect, one-dimensional.

Only small fluctuations of the water level occurred throughout the period. The dissolved oxygen concentration in the water remained fairly high during the entire time, with the exception of a three-day period, when it dropped, but not to a dangerous level. It is probable that the direction of movement, into or out of the lake, was not very strongly influenced by either current or oxygen tension. There simply was an urge to move, with little respect to direction of movement.

The daily catch numbers varied greatly during the 40-day experiment, but with definite up and down trends (Table I and Fig. 1). Extremely good correlation exists between various sets of figures: one species compared with another, one species compared with total numbers, and numbers moving in compared with numbers moving out. In Figure 1, the total number of fish caught in both nets is used to indicate the relative amount of fish movement, day by day.

Aitken (1937) suggested a correlation of fish movement under the ice with air temperature, the movement becoming intensified with the onset of warmer weather. Since water temperature, under the ice, stays within narrow bounds, 32° to 39° F., and changes but little with changes in the air temperature, it seems unlikely that air temperature can have much influence upon fish movement under the ice. Aitken went on to say that the fundamental stimulus "may be atmospheric pressures or light intensity."

Atmospheric pressure, once thought by many fishermen to exert a magic charm over fishing success, has been shown (Sieh and Parsons, 1950; and others) probably to have no influence upon fish activity. Compared to the hydrostatic pressure, and its variation with depth, the changes in atmospheric pressure are insignificant.

Water current, under the ice as in open water, can influence fish movement greatly. In the studies of winter drawdown, conducted by the Upper Mississippi River Conservation Committee, in 1944–45 and 1945–46, it was found that a lowering of the water level in the river, with a resultant current flowing out of the backwaters, produced a movement of carp, northern pike, crappie, bowfin, and several other species. The movement was from the backwater toward the main river channel, i.e., with the current, and was intensified by a rapid drawdown. The fish appeared to be moving actively, and not merely to be swept along by the current. Certain other species, such as bluegill and largemouth bass, tended to remain in the backwaters, there to become trapped by the lowered water level.

Doan (1945) demonstrated that changes in the water level, and the currents induced thereby, brought about an increase in fishing success for yellow pikeperch in western Lake Erie under the ice, by inducing or intensifying movements of the fish.

In the present study water levels remained almost stable, and currents were absent or small.

[1] Or possibly the movement was along the shore of the lake. It is a matter of conjecture. Movement patterns of fish in a given body of water have not been determined well. They may be subject to much change, under the influence of many factors.

The effect of changes in dissolved oxygen tension upon movement of fish is not known fully. Thompson (1925) claimed that fish exhibit an avoiding reaction toward low dissolved oxygen. However, Greenbank (1945) found that hundreds of fish remained at a hole in the ice until they suffocated, while at a station only 40 feet away the dissolved oxygen was 2.8 p.p.m., enough for safety and comfort. Presumably, the movement to the open hole, and the congregating there, were conditioned to a greater extent by light than by oxygen tension.

Except for a brief period, the dissolved oxygen in Target Lake was fairly high during the netting experiment. It is not likely that changes in the oxygen tension had much to do with the fish movement.

Light intensity can be a major factor in the activity of fish under the ice. Extensive creel census studies on the Upper Mississippi River (Greenbank, Ms.) produced evidence of an inverse relationship between fishing success and amount of snow on the ice. It is problematical, however, whether this apparent increase in feeding activity with an increase in the amount of light in the water meant that there actually was an increase in the movement of the fish along any given course. Instead, the activity may have been local, and the movement of an individual fish could have been only a few feet, from where it was stationed to the baited hook. In other words, with increased light in the water, the fish could see to feed better.

The data of the present study (Table I and Fig. 1) show a quite different sort of relationship. With high mathematical correlation, the fish movement was greater when the ice had a thick snow cover. A very few inches of snow are sufficient to reduce the light intensity in the water to a small fraction of that under bare ice (Greenbank, 1945). Therefore, in this instance, the greatest amount of fish movement occurred when the water under the ice was in virtual darkness. With minor variations, the relation held for the various species of fish, and for movement both into and out of the lake.

It was necessary to remake, each day, an opening of a few square feet area in the ice, in order to tend the nets. This opening provided a small spot which was better lighted than the water under the snow-covered ice, and which could have been attractive to the fish. However, the fish did not tend to congregate and to stay in the area immediately around the nets; they definitely were moving over considerable distances.

Seven inches of snow covered the ice on January 29, after it had been bare the day before, and there were ten inches on January 31. But the catch of fish in the nets did not show a striking increase until about February 2 or 3. The lag may have been due to some sort of delayed psychological response of the fish. Such a delay could explain why the nets did not fill with fish every night, even when there was no snow.

The number of fish caught reached a sharp peak on February 7 and fell off rapidly soon after. The amount of snow on the ice began to diminish on February 8. But as late as February 12, by which time the fish catch had fallen off considerably, there were still six inches of snow, enough to make it almost completely dark in the water. The abrupt reduction in fish movement, while there still was snow cover, may indicate that the movement was in the nature of a wave. Apparently significant is the sharp break, from a total of 101 fish to 18, between February 14 and 15, just a day after the snow cover dropped from four inches to zero.

From a statistical standpoint, the data are insufficient to establish absolute proof of a causal relationship between light reduction and fish movement because only about 1½ cycles are covered. The wave of movement conceivably could have been initiated by some other force, and merely have been coincidental with the period of darkness.

But, with certain other important factors, such as current, water temperature, and dissolved oxygen, largely ruled out, there is at least a strong suggestion that the movement of fish was conditioned by a reduction in light intensity.

More information is needed, concerning the movements of fish under the ice, and the connection with changes in light intensity. It is suggested that in future studies of fish movement in the winter, such as those made by the use of gill nets or trap nets in lakes, the amount of snow cover be recorded. Also, much information could be obtained from similar records made in connection with commercial fishing through the ice.

I am grateful to William E. Duellman for the preparation of Figure 1. This is a contribu-

tion of the Upper Mississippi River Conservation Committee.

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OLATHE, COLORADO.

Fossil Turtles of Friesenhahn Cave, Texas, with the Description of a New Species of *Testudo*

WILLIAM W. MILSTEAD

AN extensive collection of vertebrate fossils was made at the Friesenhahn Cave in northern Bexar County, Texas, by the Texas Memorial Museum during two periods of excavation in the summers of 1949 and 1951. This is the cave that has previously been referred to in literature (Hay, 1921; and others) as the Bulverde Cave. The collections made by the Texas Memorial Museum include large amounts of amphibian and reptilian material. Turtles make up the bulk of the reptilian specimens, but small numbers of lizard and snake bones are also present. The turtle material represents two genera and includes a small number of limb bones, one pelvic girdle, parts of two skulls, and 354 shells; some shells are represented by fragments, others are entire. The following discussion of the Friesenhahn Cave and the location of the turtle material is paraphrased from an unpublished report by Glen L. Evans.

The main chamber of the cave is about 60 feet long and 30 feet in maximum width. A vertical well-like opening, approximately 10 feet in diameter, rises to the surface from the north side of the chamber and is its only present entrance. From the northwest end of the main chamber a grotto extends upward at an inclinication of 20 to 30 degrees. This grotto is part of an older opening which has been completely filled and sealed off by accumulated debris, and is thoroughly cemented with dripstone and stalactitic materials. It is evident that the cave was sealed off, after partly filling, in a late Pleistocene time, and that the present opening originated in modern times. So far as could be seen, all modern accumulations of debris, bones, etc., are confined to a sink hole on the floor of the cave immediately beneath the present surface entrance.

The older fill, not including drip-stone and stalagmites on the floor of the cave, can be divided into four distinct units. Zone 1, the basal unit, consists of blocks of fallen limestone, iron-stained gravels, and a deep red clay in a somewhat jumbled admixture. It is separated from the overlying Zone 2 by a layer of iron oxide ⅛ to ½ of an inch thick. Zone 2 consists of slate gray, laminated clay which is characterized by numerous very thin partings of fine limestone grit. It is separated from Zone 3 above by a wavy and somewhat irregular contact. Zone 3 consists of banded clays ranging in color from deep blue-gray near the central part of the cave to mottled reddish brown near the walls. Characteristic of this zone are broad, dark bands of carbonaceous material which extend through its entire thickness. Zone 4 consists of gravel and clay which fill a definite channel that extends across the length of the chamber and disappears beneath the southeast wall.

More than 90 percent of all the fossil turtle material found in place came from the banded clay of Zone 3 where it was the most abundant element of the fauna. Both genera of turtles were found repeatedly at exactly the same level

within this zone; so there can be no question as to their contemporaneity. Although turtle material extended from the top to the bottom in Zone 3, it was most abundant at and near the base. A smaller amount of turtle material was found in place in Zone 2, and a few scraps were obtained in the lowermost part of Zone 1. Fossil material, including turtle, was also abundant in Zone 4, the channel fill. This material, however, was largely or entirely reworked from the underlying Zones 2 and 3, and was generally in broken condition.

A large Pleistocene vertebrate fauna is associated with the turtle material that was found in place. Among the most abundant forms are *Parelephas*, *Dinobastis*, *Mammut americana*, *Aenocyon*, *Bison*, and numerous smaller forms. From our present knowledge of the fauna, the deposit should be referred to one or more stages of the Wisconsin in the late Pleistocene.

Acknowledgements

Dr. John A. Wilson of the Department of Geology, University of Texas, first suggested this study to me in the Fall of 1951, and I am most grateful to him for his encouragement and supervision. Mr. Glen L. Evans has been very helpful with a number of suggestions and with information on the cave and on the collections. Drs. W. F. Blair and Clark Hubbs of the Department of Zoology, University of Texas, have also made a number of valuable suggestions. In addition, I am very grateful to the staffs of the Texas Memorial Museum, the Texas Bureau of Economic Geology, and the Texas Natural History Collection of the University of Texas for permission to work with the specimens in their collections.

Account of Species

The turtle material in the Texas Memorial Museum collections from the Friesenhahn Cave consists of a large number of fragmentary and complete shells and a small number of other bones. This material is representative of two genera, *Terrapene* and *Testudo*, with only one species of each genus being present. Hay (1921), in his report on a small collection of fossil vertebrates from the same cave, listed three species of turtles: *Gopherus atascoae* (?), *Terrapene whitneyi*, and a new species, *Terrapene bulverda*. The fragments of *Terrapene whitneyi* examined by Hay consisted of the first, second, and third marginal scutes, parts of the fourth marginal and first costal scutes, and two incomplete anterior lobes of the plastron. The fragments on which *Terrapene bulverda* was named consisted of parts of the fourth and fifth vertebral scutes, the fourth costal scute from both the right and left sides, the left third costal scute, and the left eighth, ninth, tenth, and eleventh marginal scutes. These two species of *Terrapene* will be considered in more detail below, under the discussion of *Terrapene canaliculata*. A single limb bone constituted all of the testudinid material available to Hay, and he tentatively identified it as *Gopherus atascosae*. Until there is a better knowledge of the differences between the limb bones of the various species of *Gopherus* and *Testudo*, or until undoubted *Gopherus* material is recovered from the Friesenhahn Cave, I prefer to consider Hay's specimen as belonging to the species of *Testudo* represented in the Texas Memorial Museum collections rather than to *Gopherus atascosae*.

Terrapene canaliculata Hay

Terrapene canaliculata Hay, Bull. Amer. Mus. Nat. Hist., 1907, v. 23: 850. Hay, Carnegie Instit. Wash., 1908: 363–4. Gilmore, Proc. U. S. Nat. Mus., 1927, v. 71, art. 15: 1–10. Barbour and Stetson, Bull. Mus. Comp. Zool., Harvard, 1931, v. 62, no. 8: 295–99.
Terrapene formosa Hay, Florida Geol. Surv., 8th ann. rept., 1916: 57–64.
Terrapene antipex Hay, *loc. cit.*
Terrapene innoxia Hay, *loc. cit.*
Terrapene bulverda Hay, Proc. U. S. Nat. Mus., 1921, v. 58: 83–146.
Terrapene impressa Hay, Publ. Carnegie Instit. Wash., 1924, no. 322A: 245.
Terrapene singletoni Gilmore, Proc. U. S. Nat. Mus., 1927, v. 71, art. 15: 1–10.
Terrapene llanensis Oelrich, Copeia, 1953, no. 1: 33–8.

The *Terrapene* remains in the Texas Memorial Museum collections from the Friesenhahn Cave consist of 109 complete and 34 incomplete anterior lobes of the plastron, 92 complete and 57 incomplete posterior lobes, 6 complete and 34 incomplete carapaces, a number of limb bones, one pelvic girdle, and fragments of two skulls. Two of the carapaces have the posterior plastral lobe attached and two others have both lobes attached. The shells of these fossils show every degree of variation in shape that is found in the living *Terrapene carolina*. Superficially, they differ from the living species only

TABLE I

CARAPACIC AND PLASTRAL ELEMENT RATIOS IN *Terrapene carolina* AND *T. canaliculata*

Abdo—abdominal; Ant L—anterior plastral lobe; Carp—carapace; Cost—costal; Fem—femoral; Hum—humeral; Pect—pectoral; Post L—posterior plastral lobe; Vert—vertebral

Element	*T. carolina* (southern United States)			*T. canaliculata* (Friesenhahn Cave)			*T. canaliculata* (Florida)			*T. canaliculata* (Ingleside)		
	No. of spec.	Range	Mean	No. of spec.	Range	Mean	No. of spec.	Range	Mean	No. of spec.	Range	Mean
Vert 1	50	0.53 –0.78	0.642 ±.009	123	0.47 –0.80	0.984 ±.018	7	0.78 –1.28	0.931	5	0.79 –1.08	0.936
Vert 2	53	0.75 –1.04	0.900 ±.008	122	0.74 –1.02	0.866 ±.021	8	0.87 –1.02	0.944 ±.021	5	0.88 –1.00	0.934
Vert 3	52	0.50 –0.75	0.610 ±.008	124	0.49 –0.86	0.711 ±.008	6	0.73 –0.98	0.872	5	0.73 –0.90	0.854
Vert 4	52	0.48 –0.76	0.660 ±.009	140	0.47 –0.84	0.903 ±.017	6	0.93 –1.08	1.000	4	0.90 –1.10	1.008
Vert 5	53	0.91 –1.13	0.995 ±.007	126	0.83 –1.05	0.744 ±.013	7	0.52 –0.80	0.621	3	0.57 –0.83	0.730
Cost 1	52	0.61 –0.90	0.742 ±.009	111	0.62 –0.93	0.990 ±.008	..	....	....	3	1.04 –1.07	1.050
Cost 2	52	0.67 –0.84	0.758 ±.006	102	0.71 –0.96	0.569 ±.011	..	....	....	3	0.50 –0.64	0.573
Cost 3	53	0.86 –1.07	0.965 ±.005	99	0.88 –1.06	0.607 ±.006	..	....	....	3	0.58 –0.71	0.623
Cost 4	51	0.81 –1.26	1.013 ±.016	25	0.82 –1.16	0.792 ±.013	..	....	....	3	0.77 –0.95	0.885
Carp	52	0.67 –1.00	0.817 ±.012	17	0.63 –0.99	0.760 ±.007	..	....	....	3	0.68 –0.79	0.740
Gular	51	0.52 –0.89	0.687 ±.013	14	0.67 –0.73	0.607 ±.006	..	....	....	8	0.53 –0.78	0.648 ±.026
Hum	51	0.62 –1.06	0.839 ±.015	20	0.74 –1.06	0.852 ±.005	..	....	....	9	0.76 –0.89	0.818 ±.015
Pect	53	0.52 –0.98	0.711 ±.011	23	0.60 –0.86	0.682 ±.006	..	....	....	9	0.47 –0.77	0.629 ±.033
Abdo	53	0.86 –1.09	0.962 ±.006	23	0.88 –1.04	0.602 ±.006	..	....	....	11	0.51 –0.74	0.574 ±.022
Fem	53	0.49 –0.73	0.594 ±.007	22	0.49 –0.70	0.938 ±.004	..	....	....	11	0.86 –0.98	0.909 ±.011
Anal	52	0.49 –0.74	0.613 ±.007	21	0.53 –0.67	0.729 ±.005	..	....	....	11	0.60 –0.79	0.670 ±.018
Ant L	53	0.70 –0.96	0.828 ±.009	22	0.70 –0.94	0.802 ±.004	..	....	....	7	0.78 –0.92	0.826
Post L	53	0.68 –0.92	0.791 ±.006	19	0.69 –0.82	0.960 ±.004	..	....	....	10	0.92 –1.02	0.965 ±.010

in size. The largest *T. carolina* carapace examined was 162.0 mm. in length; the largest fossil carapace was 208.0 mm. The anterior lobe of the plastron of the latter specimen was 106.0 mm. wide and the posterior one was 122.2 mm. long. A number of the free anterior and posterior lobes were larger than these. The largest anterior lobe was 121.8 mm. wide and

the largest posterior lobe was 137.0 mm. long. The pelvic girdles of the fossil and the recent species differ slightly in that there is a notch near the middle of the anterior edge of the ischium in *T. carolina*; the edge is entire in the fossils. Whether or not this difference is consistent cannot be determined on the basis of the present material. The limb bones and skulls of the fossil and the recent species exhibit no differences other than the larger size of the former.

In identifying the Friesenhahn Cave *Terrapene*, length and width measurements were taken on both lobes of the plastron, the carapace, and the scutes of both the plastron and the carapace. All measurements were taken at the greatest length and width of the unit measured. From these measurements, a number of ratios were obtained by dividing the smaller measurement of any given unit by the larger. These ratios were compared with those of other fossil material and with *Terrapene carolina* (Table I).

Fossil material other than that of the Friesenhahn Cave included one specimen in the Texas Memorial Museum from one mile north of Pilot Knob, Travis County, Texas, and 23 specimens in the Texas Bureau of Economic Geology from late Pleistocene deposits near Ingleside, San Patricio County, Texas. The specimen from Pilot Knob is indistinguishable from the Friesenhahn Cave specimens and its measurements and ratios fall within the ranges of those obtained from the latter. The 23 specimens, from the Ingleside locality included one incomplete and seven complete anterior lobes of the plastron, two incomplete and 10 complete posterior lobes, four incomplete and two complete carapaces, several limb bones, and one pelvic girdle. One of the complete carapaces has the posterior lobe of the plastron attached to it and the other has both. The limb bones and the pelvic girdle are indistinguishable from those of the Friesenhahn Cave specimens. In addition to the fossil material actually examined, the measurements and ratios of eight specimens of *Terrapene* from Florida, as published by Hay (1916a) and Gilmore (1927), were used. These specimens from Florida were originally described under the names *T. formosa*, *T. antipex*, *T. innoxia*, *T. singletoni*, and *T. canaliculata*, but Barbour and Stetson (1931) placed them all in the synonymy of *T. canaliculata*

A series of 53 specimens of *Terrapene carolina* in the Texas Natural History Collection of the University of Texas was used. These were from five states as follows: Arkansas (3), Florida (6), Louisiana (2), Oklahoma (5), and Texas (37). Included are three subspecies, as recognized by Carr (1952): *T. c. bauri*, *T. c. major*, and *T. c. triunguis*. The number of specimens of *triunguis* is much greater than that of the other two subspecies. The ratios of the specimens of *bauri* and *major* that were examined fall within the ranges of those of *triunguis*. In view of the small numbers of specimens of the two former subspecies and the similarity of the ratios, no subspecies of *Terrapene carolina* will be treated separately in the discussion below.

The ranges, means, and standard errors of the means of ratios were computed from the measurements of the scutes of *Terrapene carolina*, the Friesenhahn Cave *Terrapene*, *Terrapene canaliculata* from Florida, and the Ingleside *Terrapene* (Table I). During the course of this study, these ratios were compared graphically, using the method of Dice and Leraas (1936). Before any comparisons were made, however, the ratios of *Terrapene carolina* were plotted with the carapace lengths to see whether differences were due to ontogenetic changes. None of the graphs revealed any indication of differential growth.

The standard deviations of the ratios of *Terrapene carolina* and the fossil specimens overlap. There is an indication of a specific difference in only the third vertebral ratio. In this ratio, the means of *T. carolina* and the Friesenhahn Cave *Terrapene* are much lower than those of *T. canaliculata* from Florida and the Ingleside sample. The latter two series were not large enough to test the significance of the indicated difference statistically. No conclusions, therefore, should be based on the third vertebral ratio at this time. On the basis of the other ratios, it seems best to consider all of the fossil specimens as members of the same species, *Terrapene canaliculata*, and to re-emphasize the conclusion of Barbour and Stetson (1931) that the only distinctive difference between it and *T. carolina* lies in the larger size of the former.

Some variations between *Terrapene carolina* and *T. canaliculata* and between the three series of the latter are found in the ranges and means of the ratios (Table I). When twice the standard error of the mean is used, small

statistical differences are revealed among the four samples. In the vertebral ratios, the Ingleside sample of *canaliculata* is closer to the Florida turtles than to either the Friesenhahn ones or to *T. carolina* in all except the fifth vertebral proportion. In all of the vertebral ratios, the Ingleside specimens are closer to the Friesenhahn sample than to *T. carolina*. In the following nine ratios, not available from Florida turtles, the Ingleside specimens are closer to the Friesenhahn sample than to *T. carolina*: humeral, abdominal, pelvic, anal, anterior lobe, first costal, second costal, fifth costal, and carapace. In the following four ratios, the Ingleside specimens are closer to *carolina*: gular, pectoral, third costal, and fourth costal. The means of all three are nearly the same in only one ratio, that of the posterior lobe.

On the basis of the vertebral ratios, it appears that the Florida and Ingleside specimens of *T. canaliculata* are members of the same race; the Friesenhahn sample is intermediate between this race and *T. carolina*. On the other hand, the other ratios indicate that the Ingleside specimens are intermediate between the Friesenhahn sample and *carolina*. This problem, as well as whether or not the naming of subspecies of *canaliculata* is justifiable, will have to be set aside until the comparative ages of the fossils are known.

The fragments from the Friesenhahn Cave, identified by Hay (1921) as *Terrapene whitneyi*, showed none of the characters that distinguish it from the other species of the genus. Inasmuch as the Texas Memorial Museum collections from the Friesenhahn Cave do not contain any specimens that can be identified as *whitneyi*, I prefer to consider Hay's fragments as *Terrapene canaliculata*, at least for the present. That *whitneyi* is a species distinct from *canaliculata* is not certain to me. The original descrption of *whitneyi* given by Hay (1916b) indicates that it is more closely related to *ornata* than it is to *canaliculata* or *carolina*. The absence of a keel on the carapace, the shell shape and structure, and several other characters of *whitneyi* are those that are usually associated with *ornata*. The plate of *whitneyi* accompanying the original description does not, however, resemble *ornata* as much as does Hay's (1908) illustration of *longinsulae*. Both the carapace and plastron of this latter species bear a striking resemblance to *ornata*, and there is little doubt in my mind that the two species are closely related. If they are, then it does not seem probable that a Miocene or Pliocene relative (*longinsulae*) of *ornata* could more closely resemble the Recent species than could a Pleistocene relative (*whitneyi*). There are at least three possibilities that might explain the differences between *whitneyi* and the *ornata* complex: (1) *whitneyi* is aberrant or has affinities with species (fossil or Recent) not now known from the United States, (2) it is an anomalous form of the *ornata* complex, or (3) it is an anomalous form of the *carolina* complex. This last possibility is worthy of some detailed investigation. The most important character which separates *whitneyi* from *canaliculata* is the absence of a dorsal keel in the former. All of the Friesenhahn Cave specimens of *canaliculata* have a dorsal keel, although in some it may be almost obliterated. It is always distinct, however, on at least a part of one vertebral. A specimen, therefore, cannot be said to lack a keel if the observation is based on an incomplete series of vertebral scutes. This fact is not of too much importance in connection with *T. whitneyi* because Hay's type had all of the vertebral scutes present. It is important, however, in dealing with the fragments upon which Hay (1921) based his description of *T. bulverda*. This species was described as lacking a keel, but Hay had only parts of the fourth and fifth vertebrals in his type series. The other characters of *bulverda* do not distinguish it from the Friesenhahn Cave specimens of *canaliculata*. It seems best, therefore, on the basis of the present material, to place *bulverda* in the synonymy of *canaliculata*.

One other species, *Terrapene impressa*, described from the Pleistocene by Hay, cannot be distinguished from *canaliculata* on present material. *T. impressa* was based on a single anterior plastral lobe. The only feature noted in the original description (Hay, 1924: 245) is that the species is "characterized by the deeply and sharply impressed sulci which separate the horny plates." The sulci of both *carolina* and *canaliculata* vary from deep and sharply defined to broad and shallow. The single measurement, a width of 82 mm., and the figure which were given in the original description can be matched by a number of anterior lobes from the Friesenhahn Cave. For these reasons, I consider *T. impressa* to be a synonym of *T. canaliculata*.

Three other fossil species of *Terrapene* appear

to be closely related to *canaliculata* and possibly should be considered as synonyms of it: *putnami*, *marnochi*, and *eurypygia*. All three are distinguished from *canaliculata* and from each other on the basis of characters that might prove to be only individual variations. The Friesenhahn Cave is near the type locality of *marnochi* but an important ecological difference between the two localities devalues any suggestion that the Friesenhahn specimens and *marnochi* were members of the same population. The Friesenhahn Cave is on the Edwards Plateau; the type locality of *marnochi* is south of the Plateau in the northern part of the Texas brush country. An important reason for not placing *canaliculata*, *marnochi*, *eurypygia*, and *putnami* in synonymy at present is that the latter three names antedate the former. On the basis of the meager amount of material now available, it would be unwise and might create unnecessary complications to treat all four as one species.

Most workers on the genus *Terrapene* have been inclined to ignore one very important feature, the great amount of individual variation found within the various species. Such characters as an urn-shaped first vertebral, a well defined or poorly defined dorsal or lateral keel, an elongated or rounded shell, an enlarged marginal scute, a thick or thin shell, a narrow or broad costal or vertebral scute, etc., have been and are still being used as distinguishing characters in samples composed of small series of fragments. *T. eurypygia*, for example, was described as differing from all other species in that the tenth marginal scute borders the fifth vertebral. This species is known from only a very few specimens and these are from scattered localities. The validity of the distinguishing character is certainly subject to question when such anomalies as a fifth costal or a sixth vertebral scute are not uncommon in *T. carolina* and the Friesenhahn specimens of *T. canaliculata*.

Barbour and Stetson (1931) were the first to recognize the range of individual variation within the genus *Terrapene*. With a good series of a Recent species, they found that they could match every variation in the fossil forms. They synonymized three species, *T. formosa*, *T. inoxia*, and *T. singletoni*, with *T. canaliculata*. It was during this study that they reached their conclusion that the only difference between *canaliculata* and *carolina* lies in the larger size of the former. I am in agreement with these conclusions of Barbour and Stetson, although Oelrich (1953) suggested that *formosa*, *innoxia*, and *singletoni* are perhaps valid species.

In the same paper, a new species, *Terrapene llanensis*, from the Pleistocene of Kansas, was described as closely resembling the type of *T. canaliculata*. The characters that Oelrich used to separate the two species are, in large part, sizes and shapes of the marginal scutes. Other characters of a similar nature include development of the dorsal carina and lateral keel and the topography of the vertebral scutes. Because of the large amount of individual variation exhibited in this genus, these characters, taken either singly or in combination, do not seem valid when dealing with only a few specimens. Furthermore, and of more importance, these characters can be matched in the specimens from the Friesenhahn Cave.

In addition to the characters mentioned above, Oelrich asserted that the vertebral series of *llanensis* is broader than in *canaliculata* or *carolina*. He stated (p. 37) that, "it is significant that the width–length ratios of both the vertebral and the costal scutes lie outside the observed ratios of Recent species." When ratios are obtained from the measurements published by Oelrich, and these are compared with those computed in the present study (Table I), it becomes apparent that his observations are not sufficient for the Recent species. The ratios of *llanensis* not only fall within the ratios of the Texas specimens of *carolina*, and those of the Friesenhahn sample of *canaliculata*, but many fall very close to the means. On the basis of this evidence and that presented above, it seems best to consider *llanensis* and the Friesenhahn Cave sample as representatives of the same species. It has been concluded previously that the Friesenhahn specimens are representatives of the rather widely distributed species, *Terrapene canaliculata*. Even with the inclusion of *llanensis* and the Friesenhahn sample, however, the indicated range of *canaliculata* during the Pleistocene is not much greater than that of the present-day *carolina*.

The genus *Terrapene*, as here recognized, contains 12 species, six extinct and six living. The six extinct species include *canaliculata* (Pleistocene), *eurypygia* (Pleistocene), *longinsulae* (Pliocene or Miocene), *marnochi* (Pleisto-

cene), *putnami* (Pliocene—?), and *whitneyi* (Pleistocene). The six living species include *carolina* (Pleistocene and Recent of the United States), *coahuila* (Recent of Mexico), *klauberi* (Recent of Mexico), *mexicana* (Recent of Mexico), *nelsoni* (Recent of Mexico), and *ornata* (Pleistocene and Recent of the United States). The relationships between these species are very obscure at the present time. This is particularly true of the four species found in Mexico. All four are known only from Recent specimens, and three of them, *coahuila*, *klauberi*, and *nelsoni*, are known only from a few individuals collected at or near the type localities. No fossil specimens have thus far been reported from Mexico. The relationships between the two living species found in the United States, *carolina* and *ornata*, are somewhat more clear in that their distributions are better known and there is some knowledge of their fossil histories. If *putnami* is related to *carolina* and if *longinsulae* is related to *ornata*, it may be suggested that *carolina* and *ornata* are living representatives of two species groups that have been separated at least since lower Pliocene or upper Miocene times. The *carolina* group includes *carolina*, *canaliculata*, *eurypygia*, *marnochi*, and *putnami*. The *ornata* group includes *ornata*, *longinsulae*, and possibly *whitneyi*. Just what caused the separation of these two groups in the past is uncertain, although the present distribution of *carolina* and *ornata* may provide a clue. The former species is predominantly a forest form and is largely restricted to the eastern United States; the latter is predominantly a plains form restricted to the central United States. This distribution suggests isolation in pre-Pliocene times with subsequent adaptation to different habitats. Whether or not the four living species of *Terrapene* found in Mexico belong to the *carolina* group, or the *ornata* group, or whether they represent one or more separate species groups cannot be determined until more information is available on their geographic distribution and on the fossil history of the genus in Mexico and the southwestern United States.

A comparison of the present and past distributions of two members of the *carolina* group in Texas shows some small but noteworthy differences. The present-day range of *T. carolina* in Texas is apparently restricted to the Austroriparian and Texan biotic provinces of Blair (1950). It has not been recorded from the Balconian biotic province on the Edwards Plateau of central Texas or from the Tamaulipan of southern Texas. *T. canaliculata* has been found in the southeastern part of the Edwards Plateau (Friesenhahn Cave). It has also been found at the Ingleside locality, well within the Tamaulipan biotic province. The slight morphological differences between the Recent and Pleistocene species suggest that the former is the direct descendent of the latter. If this is so, then the presence of the Pleistocene form in two biotic provinces where the Recent species is not known to occur is indicative of one of two things: either the habitat of *canaliculata* in Pleistocene times differed from that of *carolina* in Recent times, or the climates of the eastern Edwards Plateau and the northern Tamaulipan biotic province during the late Pleistocene were similar to the present climates of the Texan or Austroriparian biotic provinces. In view of the slight differences between the two species and the short period of time involved, the latter possibility seems more plausible. The discovery of a relative of *canaliculata* in southwestern Kansas during the Pleistocene prompted Oelrich (1953) to suggest an interglacial climate for that region during the middle or late Pleistocene.

Testudo wilsoni sp. nov.

The *Testudo* remains in the Texas Memorial Museum collections from the Friesenhahn Cave consist of a small number of limb bones, three complete and 15 incomplete plastrons, three incomplete carapaces, and one almost complete shell. This material appears to represent a species that is distinct from all others previously named from Pliocene and Pleistocene deposits in the Western Hemisphere. This new species is named in honor of Dr. John A. Wilson.

DIAGNOSIS.—This is a small species that belongs to the subgenus *Hesperotestudo* (Williams, 1950). The characters of this subgenus will distinguish *Testudo wilsoni* from the subgenus *Chelonoidis* and the genus *Gopherus*, as defined by Williams (*op. cit.*), and from the subgenus *Monachilys* as defined by the same author (1952). One or more of the following characters will distinguish *T. wilsoni* from the other members of the subgenus *Hesperotestudo*: small size, carapace elliptical, sixth through eighth neurals hexagonal, pleural plates arranged in a

series of alternating wedges, marginal scutes fully as wide as the peripheral bones, epiplastral lip abruptly projecting from the margin of the plastron but not reaching beyond the edge of the nuchal, epiplastral lip notched but not deeply forked, gulars extending for a short distance on to the entoplastron, humero-pectoral sulcus located posteriorly to the entoplastron, anal scutes quadrangular, and xiphiplastral notch broad and deep.

HOLOTYPE.—The almost complete shell mentioned above has been chosen as the holotype. It is No. 933-3585 in the collections of the Texas Memorial Museum.

DESCRIPTION OF HOLOTYPE.—The type specimen of *Testudo wilsoni* agrees perfectly with the shell characters listed by Williams (1950) for the subgenus *Hesperotestudo*. The shell is elliptical and its dimensions are: length, 226 mm.; width at the suture between the fifth and sixth peripherals (widest point), 187 mm.; and height from the suture between the fourth and fifth neurals to the middle of the hypoplastron at the midline (greatest depth), 131 mm. The height is 70 percent of the width and 58 percent of the length; the width is 83 percent of the length.

Anteriorly, the epiplastral beak abruptly projects from the margin of the plastron and extends forward to a point even with the anterior edge of the nuchal. The epiplastral lip is notched but not deeply forked. Posteriorly, the plastron extends back to a point even with the inside edge of the twelfth peripherals. The xiphiplastral notch is broad and deep. The anterior border of the nuchal is concave. The first, third, and fifth neurals are quadrangular, the second and fourth are octagonal, and the sixth, seventh, and eighth are hexagonal. All of the costal bones are wider than long. The shape of the first is irregular, the second through the seventh are quadrangular, and the eighth is roughly triangular. The second, fourth, sixth, and seventh costal bones are longer distally than proximally, but the third and fifth are longer proximally than distally; this produces an effect of a series of alternating wedges, a character which Williams (1950) cited as advanced. The peripheral bones are about twice as wide as long and flare out over each leg insertion. The marginal scutes are fully as wide as the peripheral bones and some extend up onto the costal bones. The gular scutes extend posteriorly onto the entoplastron, a character cited by Williams (*op. cit.*) as primitive. The humero-pectoral sulcus passes behind the entoplastron. The pectoral scutes are broad, not constricted in the middle as they are in *Gopherus campester*, and, therefore, the humero-pectoral sulcus and the pectoro-abdominal sulcus are parallel from the midline to the bridge. The anal scutes are quadrangular and are longer distally than they are proximally.

The seventh neural is the only bone that is entirely missing from the shell. The following parts are missing from the bones of the right side: lower third of the fourth, middle third of the fifth, and upper third of the seventh pleurals; the upper halves of the sixth and seventh peripherals. The bones of the plastron and the left side of the carapace are all present and entire.

Measurements of the bones and scutes are given in Tables II and III. All measurements, taken in millimeters, are of the greatest length and width of the unit concerned.

PARATYPES.—The paratypes of *Testudo wilsoni*, all in the collections of the Texas Memorial Museum, consist of three incomplete carapaces (Nos. 933-1186, -1273, -3162), three complete plastrons (933-387, -1599, -2518) and 15 incomplete plastrons (933-801, -949, -1179, -1273, -1450, -1597, -1598, -1719, -1720, -1725, -1754, -3326, -3446, -3448, and -3552). Only one set of measurements, those of the fourth costal scute, was possible on specimen No. 933-1186: length 66.0 mm., width 69.0 mm. (ratio 0.96). Measurements of the other specimens are given in Table II.

Most of the plastron ratios of the holotype are very close to the means of those of the paratypes (Table III). In only the pectoral scute does the ratio of the type specimen fall outside of the observed range. When the small number of specimens and the comparatively low range of variation in this particular ratio are taken into consideration, this difference does not appear to be of much importance. The same statement may be made for most of the differences that exist between the carapace ratios of the holotype and those of the paratypes. The greatest difference in the carapace ratios involves the second suprapygal, 0.64 in the type and 0.96 in No. 933-1273, a difference of 0.32. The greatest range of variation in any of the other ratios is 0.31 in the hypoplastron.

TABLE II

MEASUREMENTS AND LENGTH–WIDTH RATIOS OF BONES AND SCUTES IN THE TYPE (No. 933-3585) AND TWO PARATYPES OF *Testudo wilsoni*

Ent—entoplastron; Epi—epiplastron; Hyo—hyoplastron; Hypo—hypoplastron; Neu—neural; Nuc—nuchal; Plast—plastron; Pleu—pleural; Supr—suprapygal; Xiphi—xiphiplastron. Other abbreviations as in Table I

Element	No. 933-3585			No. 933-1273			No. 933-3162		
	Length	Width	Ratio	Length	Width	Ratio	Length	Width	Ratio
Nuc	48.4	61.2	0.79	50.0	60.6	0.83	50.0	58.3	0.86
Neu 1	24.7	18.2	1.36	....	....	....	29.5	21.1	1.40
Neu 2	23.5	32.5	0.72	....	....	....	23.0	30.2	0.76
Neu 3	22.5	28.8	0.78	....	....	....	20.0	27.0	0.75
Neu 4	25.2	36.8	0.68	....	....	....	23.4	39.0	0.60
Neu 5	22.0	32.3	0.68	....	....	....	20.2	31.2	0.65
Neu 6	19.5	33.3	0.59	....	....	....	....	....	....
Neu 7	22.4	33.4	0.67	....	....	....	....	....	....
Neu 8	19.6	24.5	0.80	....	....	....	....	....	....
Sup 1	13.2	19.7	0.67	27.0	21.0	1.28	....	....	....
Sup 2	34.8	54.4	0.64	26.6	25.5	1.04	....	....	....
Pleu 1	40.3	75.6	0.53	....	....	....	43.9	71.0	0.62
Pleu 2	32.9	79.6	0.41	....	....	....	25.9	76.7	0.34
Pleu 3	21.7	88.7	0.24	....	....	....	22.3	82.5	0.27
Pleu 4	28.9	88.2	0.33	....	....	....	....	....	....
Pleu 5	25.4	77.5	0.33	....	....	....	....	....	....
Pleu 6	31.2	83.9	0.37	....	....	....	....	....	....
Pleu 7	24.8	70.7	0.35	....	....	....	....	....	....
Pleu 8	35.0	55.4	0.63	....	....	....	....	....	....
Ento	41.3	41.9	0.99	....	....	....	....	....	....
Epi	44.2	41.2	1.07	....	....	....	....	....	....
Hyo	75.2	78.5	0.96	....	....	....	....	....	....
Hypo	63.7	75.0	0.85	....	....	....	....	....	....
Xiphi	46.9	45.4	1.03	....	....	....	....	....	....
Plast	205.0	163.0	1.26	....	....	....	....	....	....
Carp	226.0	187.0	1.21	....	185.0	....	....	....	....
Vert 1	44.0	53.0	0.83	49.6	60.7	0.82	46.5	54.1	0.86
Vert 2	43.9	56.3	0.80	47.5	54.4	0.87	40.4	56.1	0.72
Vert 3	47.1	67.5	0.70	42.3	62.3	0.69	44.3	65.6	0.68
Vert 4	56.4	61.9	0.91	49.0	58.6	0.84	....	....	....
Vert 5	47.0	82.5	0.60	54.0	75.5	0.72	....	....	....
Cost 1	54.0	66.4	0.81	60.2	65.5	0.92	....	....	....
Cost 2	46.9	76.5	0.61	48.0	75.9	0.63	....	....	....
Cost 3	49.8	77.8	0.64	50.0	78.3	0.64	....	....	....
Cost 4	57.3	67.0	0.86	54.5	57.4	0.95	....	....	....
Gular	35.9	20.2	1.78	....	....	....	....	....	....
Hum	57.2	47.0	1.22	....	....	....	....	....	....
Pect	52.7	84.5	0.62	....	....	....	....	....	....
Abdo	68.4	82.5	0.83	....	....	....	....	....	....
Fem	44.6	51.0	0.87	....	....	....	....	....	....
Anal	35.2	34.4	1.02	....	....	....	....	....	....

COMPARISON.—*Testudo wilsoni* appears to be more closely related to *T. angusticeps*, from Miocene deposits of Nebraska, than to any of the other known members of the subgenus *Hesperotestudo*. *T. wilsoni* and *T. angusticeps* resemble each other in size, general shape and thickness of the shell, general shape of the scutes, and in the notching and shape of the

TABLE III

PROPORTIONAL MEASUREMENTS OF THE PLASTRON OF *Testudo wilsoni*

Ratios are length–width unless otherwise indicated. Abbreviations as in Table II

Element	No. of spec.	Range	Mean	Type	Mean (type included)
Ento	8	0.83–1.05	0.975	0.99	0.977 ± .031
Epi (W/L)	9	0.86–1.08	0.971	0.93	0.967 ± .024
Hyo	9	0.89–1.20	0.962	0.96	0.962 ± .028
Hypo	6	0.73–0.90	0.797	0.85	0.804 ± .021
Xiphi	6	0.90–1.07	0.983	1.03	0.990 ± .023
Gular (W/L)	9	0.50–0.67	0.580	0.56	0.578 ± .016
Hum (W/L)	10	0.83–1.00	0.911	0.82	0.903 ± .016
Pect	8	0.42–0.54	0.480	0.62	0.496 ± .021
Abdo	2	0.59–0.84	0.715	0.83	0.753
Fem	6	0.78–0.95	0.870	0.87	0.870 ± .023
Anal	6	0.77–1.05	0.918	1.02	0.933 ± .035
Plast (W/L)	2	0.71–0.80	0.755	0.80	0.770

epiplasteral lip. *T. wilsoni* differs from *T. angusticeps* in the following ways: *T. wilsoni* is somewhat more elliptical; the sixth, seventh, and eighth neurals are definitely hexagonal; the pleural plates are more definitely wedge-shaped; the epiplastral lip does not project beyond the anterior margin of the plastron; the xiphiplastral notch is broader and deeper; and the anal scutes are more definitely wedge-shaped and proportionately broader. A determination of the actual relationships between these two species and between *T. wilsoni* and the other members of the subgenus *Hesperotestudo* must await a better knowledge of the smaller testudines of the Miocene, Pliocene, and Pleistocene epochs.

SUMMARY

The fossil turtle material in the Texas Memorial Museum collections from the Friesenhahn Cave, Bexar County, Texas, represents two species of two genera: *Terrapene canaliculata* and a new species, *Testudo wilsoni*.

The specimens of *Terrapene canaliculata*, which compose the largest amount of the material from the cave, were compared with specimens of the living *Terrapene carolina*; with specimens of *T. canaliculata* found near Ingleside, Texas; with one found near Austin, Texas; and with published descriptions of specimens found in Florida. Reasons are given for placing *T. bulverda*, *T. impressa*, and *T. llanensis* in the synonymy of *T. canaliculata*; and the genus *Terrapene*, as now known, is briefly reviewed. The distributions of *T. canaliculata* and *T. carolina* in Texas are discussed as being a possible indication of a climatic change between late Pleistocene and Recent times.

The new species of *Testudo* is named *wilsoni* in honor of Dr. John A. Wilson. It is placed in the subgenus *Hesperotestudo* and, within this group, *T. angusticeps* from the Miocene of Nebraska is suggested as a possible ancestor of *T. wilsoni*.

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Common Names for North American Amphibians and Reptiles

A COMMITTEE on Herpetological Common Names was appointed early in 1953 by Charles M. Bogert, immediate Past-President of the American Society of Ichthyologists and Herpetologists. It was charged with the preparation of a list of common names for North American reptiles and amphibians suitable for use by zoo and museum personnel, other writers of labels, guide books, and popular handbooks, camp counselors, biology teachers, professional zoologists whose chief interest is not in herpetology, and anyone else who could make profitable use of such a standard list of names.

The original Committee consisted of Hobart M. Smith (Chairman), Fred R. Cagle, Roger Conant, Coleman J. Goin, and Robert C. Stebbins. Early in 1954, Dr. Smith resigned and several additional Committee members were appointed; viz. Charles H. Lowe, Jr., Wilfred T. Neill, M. Graham Netting, Karl P. Schmidt, and Charles E. Shaw. At Mr. Bogert's request, Mr. Conant accepted the Chairmanship of the expanded Committee.

Because of the recent publication of the sixth edition of *A Check List of North American Amphibians and Reptiles* (Schmidt, 1953, Univ. Chicago Press, viii + 280 pp.), which features the important innovation of including common names, that volume has served as the basis for the Committee's deliberations. Members of the Committee and members at large of the ASIH were invited to suggest names, and a total in excess of 600 was submitted. All these names were reviewed and voted upon by the Committee during the meetings of the ASIH in Gainesville, in September, 1954. Eight of the nine members of the Committee attended these sessions. In general, each member concerned himself mainly with those forms existing in his own part of the country or those with which he was especially familiar.

It was agreed from the beginning that only one name would be selected for any form, except in those instances involving marked dimorphism (*i.e.*, the black and red phases of *Masticophis flagellum piceus*) or forms displaying marked changes during certain periods of their life histories (*i.e.*, the terrestrial and aquatic stages of *Diemictylus viridescens viridescens*). It was also agreed to retain names of long-standing usage wherever possible, and to give preference to names that are truly "common" in the sense of being applied by fishermen, country folk, and laymen in general. Hence, the names we have selected do not necessarily reflect taxonomy. Most patronymics have been eliminated, but a few that have long appeared in the literature (*i.e.*, Fowler's Toad, Jefferson Salamander, etc.) are retained. Short names were usually given consideration over long ones.

In selecting common names, no cognizance was taken, in many instances, of Mexican or other extralimital races. Thus the species *Crotalus ruber* and its only subspecies occurring within the borders of the United States, *Crotalus ruber ruber*, are both called simply Red Rattlesnake; no modifier is employed to distinguish this subspecies from the Mexican *Crotalus ruber lucasensis*. *Drymarchon corais* is called Indigo Snake even though the tropical races may not merit the name. Capitalization of common names is not considered obligatory.

Aside from these generalized tenets, the Committee agreed to have no rules, to set up no machinery for amending the list, and, in short, to make the list informal and as free as possible from the legalistic practices that have plagued binomial nomenclature. If some of the selections fail to meet with popular approval, they can be changed by a future committee. We would hope, however, that the policy of continuity, now finding so much favor among systematic zoologists, would help to guide any such future committee.

Our selections should be considered as recommendations only. These names have no official status, and their use is in no way compulsory. Workers who hold that common names have no place in scientific zoological literature may ignore them. Such workers, however, might do well to read the following paragraph quoted from George Wald (Biochemical Evolution, *in* Trends in Physiology and Biochemistry, Edited by E. S. Guzman Barron, Academic Press, N. Y., 1952: 337–376).

"In the original version of this table, Nuttall mentions *Cynocephalus mormon* and *sphinx*, omitting their common names. I have learned since that one is the mandrill and the other the

guinea baboon. Since Nuttall wrote in 1904, these names have undergone the following vagaries: *Cynocephalus mormon* became *Papio mormon*, otherwise *Papio maimon*, which turned to *Papio sphinx*. This might well have been confused with *Cynocephalus*, now become *Papio*, *sphinx*, had not the latter meanwhile been turned into *Papio papio*. This danger averted, *Papio sphinx* now became *Mandrillus sphinx*, while *Papio papio* became *Papio comatus*. All I can say to this is, thank heavens one is called the mandrill and the other the guinea baboon. Anyone who supposes, as Nuttall apparently did, that he improves matters by giving their taxonomic designations is only asking for trouble, and is more likely to mislead the reader than to inform him."

The binomial and trinomial nomenclature that we use below is taken from the sixth edition of the *Check List*. We have added new species and new subspecies that have been described since the *Check List* went to press as of December 31, 1951. We have also added those names that have been resurrected from synonymy since the same date. (References to the literature are given in the appropriate places.) Conversely, certain names included in the *Check List* have recently been relegated to synonymy. We have retained such names in the list, but have appended references to the papers in which they were suppressed.

The addition of names to our list is not tantamount to recognition of them by the Committee as a whole. We have simply suggested common names for the several forms. Our function is not to sit in judgement upon the validity of any species or subspecies or the names used for them. Thus, we have not concerned ourselves with names that various authors would substitute for certain of those used in the *Check List*. Nor have we shifted the status of species to subspecies, or vice versa, even though arguments for such changes may have appeared in the literature. In most such instances, the common names we have selected would apply equally well; although the scientific names may change, the common names will tend to remain the same. We have closed our list as of December 31, 1955.

The Committee wishes to thank the many persons who have taken an interest in its work and who have assisted in various ways. Robert G. Hudson, Edmond V. Malnate, William J. Riemer, and Jay M. Savage have been especially helpful.

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SALAMANDERS

Ambystoma—Mole Salamanders

Ambystoma annulatum—Ringed Salamander
Ambystoma cingulatum—Flatwoods Salamander
Ambystoma c. cingulatum—Frosted Flatwoods Salamander
Ambystoma c. bishopi—Reticulated Flatwoods Salamander
Ambystoma gracile—Northwestern Salamander
Ambystoma g. gracile—Brown Salamander
Ambystoma g. decorticatum—British Columbia Salamander
Ambystoma jeffersonianum—Jefferson Salamander
Ambystoma laterale—Blue-spotted Salamander (Minton, Herpetologica, 10: 174)
Ambystoma mabeei—Mabee's Salamander
Ambystoma macrodactylum—Long-toed Salamander
Ambystoma maculatum—Spotted Salamander
Ambystoma opacum—Marbled Salamander
Ambystoma talpoideum—Mole Salamander
Ambystoma texanum—Small-mouthed Salamander
Ambystoma tigrinum—Tiger Salamander
Ambystoma t. tigrinum—Eastern Tiger Salamander
Ambystoma t. californiense—California Tiger Salamander
Ambystoma t. diaboli—Gray Tiger Salamander
Ambystoma t. mavortium—Barred Tiger Salamander
Ambystoma t. melanostictum—Blotched Tiger Salamander
Ambystoma t. nebulosum—Arizona Tiger Salamander
Ambystoma t. stebbinsi—Sonora Tiger Salamander (Lowe, Proc. Biol. Soc. Wash., 67: 243)
Ambystoma t. utahense—Utah Tiger Salamander (Lowe, Trans. Kansas Acad. Sci., 58: 246)

Amphiuma—Amphiumas

Amphiuma means—Amphiuma
Amphiuma m. means—Two-toed Amphiuma
Amphiuma m. tridactylum—Three-toed Amphiuma

Aneides—Climbing Salamanders

Aneides aeneus—Green Salamander
Aneides ferreus—Clouded Salamander
Aneides flavipunctatus—Black Salamander
Aneides f. flavipunctatus—Speckled Black Salamander
Aneides f. niger—Santa Cruz Black Salamander
Aneides hardyi—Sacramento Mountain Salamander
Aneides lugubris—Arboreal Salamander
Aneides l. lugubris—Oak Salamander
Aneides l. farallonensis—Farallon Island Salamander

Batrachoseps—Slender Salamanders

Batrachoseps attenuatus—California Slender Salamander

Batrachoseps a. attenuatus—Northern Slender Salamander
Batrachoseps a. leucopus—Southern Slender Salamander
Batrachoseps pacificus—Pacific Slender Salamander
Batrachoseps p. pacificus—Channel Islands Slender Salamander
Batrachoseps p. catalinae—Santa Catalina Slender Salamander
Batrachoseps p. major—Garden Slender Salamander
Batrachoseps wrighti—Oregon Slender Salamander
NOTE—Most of the races of *Batrachoseps* have been suppressed by Hendrickson (Univ. California Publ. Zool., 54: 19-23)

Cryptobranchus—Hellbenders

Cryptobranchus alleganiensis—Hellbender
Cryptobranchus a. alleganiensis—Hellbender
Cryptobranchus a. bishopi—Ozark Hellbender

Desmognathus—Dusky Salamanders

Desmognathus aeneus—Cherokee Salamander
Desmognathus chermocki—Alabama Salamander
Desmognathus fuscus—Dusky Salamander
Desmognathus f. fuscus—Northern Dusky Salamander
Desmognathus f. auriculatus—Southern Dusky Salamander
Desmognathus f. brimleyorum—Central Dusky Salamander
Desmognathus f. carri—Peninsula Dusky Salamander
Desmognathus f. welteri—Black Mountain Dusky Salamander
Desmognathus monticola—Seal Salamander
Desmognathus m. monticola—Appalachian Seal Salamander
Desmognathus m. jeffersoni—Virginia Seal Salamander
Desmognathus ochrophaeus—Mountain Salamander
Desmognathus o. ochrophaeus—Allegheny Mountain Salamander
Desmognathus o. carolinensis—Blue Ridge Mountain Salamander
Desmognathus ocoee—Ocoee Salamander
Desmognathus perlapsus—Cliffside Salamander
Desmognathus planiceps—Flat-headed Salamander (Newman, Journ. Washington Acad. Sci., 45: 83)
Desmognathus quadramaculatus—Black-bellied Salamander
Desmognathus wrighti—Pigmy Salamander

Dicamptodon—Pacific Giant Salamander

Dicamptodon ensatus—Pacific Giant Salamander

Diemictylus—Eastern Newts

Diemictylus meridionalis—Black-spotted Newt
Diemictylus viridescens—Newt
Diemictylus v. viridescens—Red-spotted Newt, Red Eft (for the land stage)
Diemictylus v. dorsalis—Broken-striped Newt
Diemictylus v. louisianensis—Central Newt
Diemictylus v. perstriatus—Striped Newt
Diemictylus v. piaropicola—Peninsula Newt (Schwartz and Duellman, Bull. Chicago Acad. Sci., 9: 219)

Ensatina—Ensatinas

Ensatina eschscholtzi—Ensatina
Ensatina e. eschscholtzi—Monterey Salamander
Ensatina e. croceater—Yellow-blotched Salamander
Ensatina e. klauberi—Large-blotched Salamander
Ensatina e. oregonensis—Oregon Salamander
Ensatina e. picta—Painted Salamander
Ensatina e. platensis—Sierra Nevada Salamander
Ensatina e. xanthoptica—Yellow-eyed Salamander

Eurycea—Brook Salamanders

Eurycea bislineata—Two-lined Salamander
Eurycea b. bislineata—Northern Two-lined Salamander
Eurycea b. cirrigera—Southern Two-lined Salamander
Eurycea b. rivicola—Midwest Two-lined Salamander
Eurycea b. wilderae—Blue Ridge Two-lined Salamander
Eurycea longicauda—Long-tailed Salamander
Eurycea l. longicauda—Long-tailed Salamander
Eurycea l. guttolineata—Three-lined Salamander
Eurycea l. melanopleura—Dark-sided Salamander
Eurycea l. pernix—Midland Long-tailed Salamander
Eurycea lucifuga—Cave Salamander
Eurycea multiplicata—Many-ribbed Salamander
Eurycea m. multiplicata—Many-ribbed Salamander
Eurycea m. griseogaster—Gray-bellied Salamander
Eurycea neotenes—Texas Salamander
Eurycea n. neotenes—Bexar County Salamander
Eurycea n. latitans—Cascade Cavern Salamander
Eurycea n. nana—San Marcos Salamander
Eurycea n. pterophila—Fern Bank Salamander
Eurycea tynerensis—Oklahoma Salamander

Gyrinophilus—Spring Salamanders

Gyrinophilus danielsi—Mountain Spring Salamander
Gyrinophilus d. danielsi—Blue Ridge Spring Salamander
Gyrinophilus d. dunni—Carolina Spring Salamander
Gyrinophilus d. polystictus—Mount Mitchell Spring Salamander
Gyrinophilus lutescens—Kentucky Cave Salamander
Gyrinophilus palleucus—Tennessee Cave Salamander (McCrady, Copeia, 1954: 201)
Gyrinophilus porphyriticus—Spring Salamander
Gyrinophilus p. porphyriticus—Northern Spring Salamander
Gyrinophilus p. duryi—Kentucky Spring Salamander
Gyrinophilus p. inagnoscus—Ohio Spring Salamander

Haideotriton—Georgia Blind Salamander

Haideotriton wallacei—Georgia Blind Salamander

Hemidactylium—Four-toed Salamander

Hemidactylium scutatum—Four-toed Salamander

Hydromantes—Web-toed Salamanders

Hydromantes brunus—Limestone Salamander (Gorman, Herpetologica, 10: 153)
Hydromantes platycephalus—Mount Lyell Salamander

Hydromantes shastae—Shasta Salamander (Gorman, Copeia, 1953: 39)

Leurognathus—Shovel-nosed Salamanders

Leurognathus marmorata—Shovel-nosed Salamander
Leurognathus m. marmorata—Northern Shovel-nosed Salamander
Leurognathus m. intermedia—Southern Shovel-nosed Salamander

Manculus—Dwarf Salamander

Manculus quadridigitatus—Dwarf Salamander

Necturus—Waterdogs and Mudpuppies

Necturus lodingi—Mobile Waterdog
Necturus maculosus—Waterdog
Necturus m. maculosus—Mudpuppy
Necturus m. beyeri—Gulf Coast Waterdog
Necturus m. lewisi—Neuse River Waterdog
Necturus m. louisianensis—Red River Waterdog
Necturus m. stictus—Lake Winnebago Mudpuppy
Necturus punctatus—Dwarf Waterdog

Plethodon—Woodland Salamanders

Plethodon caddoensis—Caddo Mountain Salamander
Plethodon cinereus—Red-backed Salamander
Plethodon c. cinereus—Red-backed Salamander, Lead-backed Salamander (names for the two color phases)
Plethodon c. angusticlavius—Ozark Red-backed Salamander
Plethodon c. serratus—Ouachita Red-backed Salamander
Plethodon dixi—Roanoke Salamander
Plethodon dorsalis—Zigzag Salamander
Plethodon dunni—Dunn's Salamander
Plethodon elongatus—Del Norte Salamander
Plethodon glutinosus—Slimy Salamander
Plethodon g. glutinosus—Slimy Salamander
Plethodon g. albagula—White-throated Slimy Salamander
Plethodon g. chlorobryonis—Carolina Slimy Salamander
Plethodon g. grobmani—Florida Slimy Salamander
Plethodon huldae—Shenandoah Salamander (suppressed by Muchmore, Copeia, 1955: 172 and Rabb, Copeia, 1955: 262)
Plethodon jacksoni—Blacksburg Salamander (Newman, Herpetologica, 10: 9)
Plethodon jordani—Jordan's Salamander
Plethodon j. jordani—Red-cheeked Salamander
Plethodon j. clemsonae—Clemson Salamander
Plethodon j. kentucki—Kentucky Salamander (suppressed by Clay, Case and Cunningham, Trans. Kentucky Acad. Sci., 16: 65)
Plethodon j. melaventris—Highlands Salamander
Plethodon j. metcalfi—Metcalf's Salamander
Plethodon j. rabunensis—Rabun Salamander
Plethodon j. shermani—Red-legged Salamander
Plethodon j. teyahalee—Teyahalee Salamander
Plethodon neomexicanus—Jemez Mountains Salamander
Plethodon nettingi—Cheat Mountain Salamander
Plethodon ouachitae—Rich Mountain Salamander
Plethodon richmondi—Ravine Salamander
Plethodon vandykei—Van Dyke's Salamander
Plethodon v. vandykei—Washington Salamander
Plethodon v. idahoensis—Coeur D'Alene Salamander
Plethodon v. larselli—Larch Mountain Salamander (Burns, Herpetologica, 10: 83)
Plethodon vehiculum—Western Red-backed Salamander
Plethodon wehrlei—Wehrle's Salamander
Plethodon welleri—Weller's Salamander
Plethodon yonahlossee—Yonahlossee Salamander

Pseudobranchus—Dwarf Sirens

Pseudobranchus striatus—Dwarf Siren
Pseudobranchus s. striatus—Broad-striped Dwarf Siren
Pseudobranchus s. axanthus—Narrow-striped Dwarf Siren
Pseudobranchus s. belli—Everglades Dwarf Siren (Schwartz, Nat. Hist. Misc., 115: 1)
Pseudobranchus s. lustricolus—Gulf Hammock Dwarf Siren
Pseudobranchus s. spheniscus—Slender Dwarf Siren

Pseudotriton—Red Salamanders

Pseudotriton montanus—Mud Salamander
Pseudotriton m. montanus—Eastern Mud Salamander
Pseudotriton m. diastictus—Midland Mud Salamander
Pseudotriton m. flavissimus—Gulf Coast Mud Salamander
Pseudotriton m. floridanus—Rusty Mud Salamander
Pseudotriton ruber—Red Salamander
Pseudotriton r. ruber—Northern Red Salamander
Pseudotriton r. nitidus—Blue Ridge Red Salamander
Pseudotriton r. schencki—Black-chinned Red Salamander
Pseudotriton r. vioscai—Southern Red Salamander

Rhyacotriton—Olympic Salamanders

Rhyacotriton olympicus—Olympic Salamander
Rhyacotriton o. olympicus—Northern Olympic Salamander
Rhyacotriton o. variegatus—Southern Olympic Salamander

Siren—Sirens

Siren intermedia—Lesser Siren
Siren i. intermedia—Eastern Lesser Siren
Siren i. nettingi—Western Lesser Siren
Siren lacertina—Greater Siren

Stereochilus—Many-lined Salamander

Stereochilus marginatus—Many-lined Salamander

Taricha—Pacific Newts

Taricha granulosa—Rough-skinned Newt
Taricha g. granulosa—Northern Rough-skinned Newt
Taricha g. mazamae—Crater Lake Newt
Taricha g. similans—Mendocino Newt
Taricha g. twittyi—Southern Rough-skinned Newt
Taricha rivularis—Red-bellied Newt
Taricha torosa—California Newt
Taricha t. torosa—Coast Range Newt
Taricha t. sierrae—Sierra Newt

Typhlomolge—Texas Blind Salamander

Typhlomolge rathbuni—Texas Blind Salamander

Typhlotriton—Grotto Salamanders

Typhlotriton nereus—Spring Grotto Salamander
Typhlotriton spelaeus—Grotto Salamander

FROGS AND TOADS

Acris—Cricket Frogs

Acris gryllus—Cricket Frog
Acris g. gryllus—Southern Cricket Frog
Acris g. blanchardi—Blanchard's Cricket Frog
Acris g. crepitans—Northern Cricket Frog
Acris g. dorsalis—Florida Cricket Frog
Acris g. paludicola—Coastal Cricket Frog

Ascaphus—Tailed Frogs

Ascaphus truei—Tailed Frog
Ascaphus t. truei—Olympic Tailed Frog
Ascaphus t. californicus—California Tailed Frog
Ascaphus t. montanus—Rocky Mountain Tailed Frog

Bufo—Toads

Bufo alvarius—Colorado River Toad
Bufo boreas—Western Toad
Bufo b. boreas—Boreal Toad
Bufo b. exsul—Black Toad
Bufo b. halophilus—California Toad
Bufo b. nelsoni—Amargosa Toad
Bufo canorus—Yosemite Toad
Bufo cognatus—Great Plains Toad
Bufo compactilis—Texas Toad
Bufo c. speciosus—Texas Toad
Bufo debilis—Green Toad
Bufo d. debilis—Eastern Green Toad
Bufo d. insidior—Western Green Toad
Bufo d. retiformis—Sonora Green Toad
Bufo houstonensis—Houston Toad (Sanders, Herpetologica, 9: 27)
Bufo marinus—Giant Toad
Bufo microscaphus—Southwestern Toad
Bufo m. microscaphus—Arizona Toad
Bufo m. californicus—Arroyo Toad
Bufo punctatus—Red-spotted Toad
Bufo quercicus—Oak Toad
Bufo terrestris—Common American Toad
Bufo t. terrestris—Southern Toad
Bufo t. americanus—American Toad
Bufo t. charlesmithi—Dwarf American Toad (Bragg Wasmann Journ. Biol., 12: 245)
Bufo t. copei—Hudson Bay Toad
Bufo valliceps—Gulf Coast Toad
Bufo woodhousei—Woodhouse's Toad
Bufo w. woodhousei—Rocky Mountain Toad
Bufo w. australis—Southwestern Woodhouse's Toad (Shannon and Lowe, Herpetologica, 11: 185)
Bufo w. fowleri—Fowler's Toad
Bufo w. hemiophrys—Dakota Toad
Bufo w. velatus—East Texas Toad

Eleutherodactylus—Robber Frogs

Eleutherodactylus augusti—Western Barking Frog
Eleutherodactylus latrans—Barking Frog
Eleutherodactylus ricordi—Greenhouse Frog
Eleutherodactylus r. planirostris—Greenhouse Frog

Hyla—Treefrogs

Hyla andersoni—Pine Barrens Treefrog
Hyla arenicolor—Canyon Treefrog
Hyla baudini—Mexican Treefrog
Hyla cinerea—Green Treefrog
Hyla c. cinerea—Green Treefrog
Hyla c. evittata—Northern Green Treefrog
Hyla crucifer—Spring Peeper
Hyla c. crucifer—Northern Spring Peeper
Hyla c. bartramiana—Southern Spring Peeper
Hyla eximia—Arizona Treefrog
Hyla e. wrightorum—Arizona Treefrog
Hyla femoralis—Pine Woods Treefrog
Hyla gratiosa—Barking Treefrog
Hyla ocularis—Little Grass Frog
Hyla phaeocrypta—Bird-voiced Treefrog
Hyla p. phaeocrypta—Western Bird-voiced Treefrog
Hyla p. ogechiensis—Eastern Bird-voiced Treefrog
Hyla regilla—Pacific Treefrog
Hyla septentrionalis—Cuban Treefrog
Hyla squirella—Squirrel Treefrog
Hyla versicolor—Gray Treefrog
Hyla v. versicolor—Eastern Gray Treefrog
Hyla v. chrysoscelis—Southern Gray Treefrog
Hyla v. sandersi—Central Texas Treefrog

Hypopachus—Sheep Frogs

Hypopachus cuneus—Sheep Frog
Hypopachus c. cuneus—Sheep Frog

Leptodactylus—Nest-building Frogs

Leptodactylus labialis—Mexican White-lipped Frog

Microhyla—Narrow-mouthed Toads

Microhyla carolinensis—Narrow-mouthed Toad
Microhyla c. carolinensis—Eastern Narrow-mouthed Toad
Microhyla c. mazatlanensis—Sinaloa Narrow-mouthed Toad
Microhyla c. olivacea—Great Plains Narrow-mouthed Toad

Pseudacris—Chorus Frogs

Pseudacris brachyphona—Mountain Chorus Frog
Pseudacris brimleyi—Brimley's Chorus Frog
Pseudacris clarki—Spotted Chorus Frog
Pseudacris nigrita—Chorus Frog
Pseudacris n. nigrita—Southern Chorus Frog
Pseudacris n. feriarum—Upland Chorus Frog
Pseudacris n. kalmi—New Jersey Chorus Frog (Harper, Nat. Hist. Misc., 150: 1)
Pseudacris n. septentrionalis—Boreal Chorus Frog
Pseudacris n. triseriata—Western Chorus Frog
Pseudacris n. verrucosa—Florida Chorus Frog
Pseudacris ornata—Ornate Chorus Frog
Pseudacris streckeri—Strecker's Chorus Frog
Pseudacris s. streckeri—Strecker's Chorus Frog
Pseudacris s. illinoisensis—Illinois Chorus Frog

Rana—True Frogs

Rana areolata—Crawfish Frog
Rana a. areolata—Southern Crawfish Frog
Rana a. circulosa—Northern Crawfish Frog
Rana aurora—Red-legged Frog
Rana a. aurora—Northern Red-legged Frog
Rana a. cascadae—Cascades Frog
Rana a. draytoni—California Red-legged Frog
Rana boylei—Yellow-legged Frog
Rana b. boylei—California Yellow-legged Frog
Rana b. muscosa—San Bernardino Yellow-legged Frog
Rana b. sierrae—Sierra Yellow-legged Frog
Rana capito—Gopher Frog

Rana c. capito—Florida Gopher Frog
Rana c. sevosa—Dusky Gopher Frog
Rana catesbeiana—Bullfrog
Rana clamitans—Green Frog
Rana c. clamitans—Bronze Frog (Mecham, Texas Journ. Sci., 6: 21)
Rana c. melanota—Green Frog (Mecham, Texas Journ. Sci., 6: 23)
Rana grylio—Pig Frog
Rana heckscheri—River Frog
Rana palustris—Pickerel Frog
Rana pipiens—Leopard Frog
Rana p. pipiens—Northern Leopard Frog
Rana p. berlandieri—Rio Grande Leopard Frog
Rana p. brachycephala—Western Leopard Frog
Rana p. fisheri—Vegas Valley Leopard Frog
Rana p. sphenocephala—Southern Leopard Frog
Rana pretiosa—Spotted Frog
Rana p. pretiosa—Western Spotted Frog
Rana p. luteiventris—Great Basin Spotted Frog
Rana septentrionalis—Mink Frog
Rana sylvatica—Wood Frog
Rana s. sylvatica—Eastern Wood Frog
Rana s. cantabrigensis—Northern Wood Frog
Rana s. cherokiana—Cherokee Wood Frog (Witschi, Proc. Iowa Acad. Sci., 60: 765)
Rana tarahumarae—Tarahumara Frog
Rana virgatipes—Carpenter Frog

Scaphiopus—Spadefoot Toads

Scaphiopus bombifrons—Plains Spadefoot
Scaphiopus couchi—Couch's Spadefoot
Scaphiopus hammondi—Western Spadefoot
Scaphiopus h. hammondi—Hammond's Spadefoot
Scaphiopus h. intermontanus—Great Basin Spadefoot
Scaphiopus holbrooki—Eastern Spadefoot
Scaphiopus h. holbrooki—Eastern Spadefoot
Scaphiopus h. albus—Key West Spadefoot (suppressed by Duellman, Copeia, 1955: 143)
Scaphiopus h. hurteri—Hurter's Spadefoot

Syrrhophus—Chirping Frogs

Syrrhophus campi—Rio Grande Frog
Syrrhophus marnocki—Cliff Frog

Turtles

Caretta—Loggerhead Turtles

Caretta caretta—Loggerhead
Caretta c. caretta—Atlantic Loggerhead
Caretta c. gigas—Pacific Loggerhead

Chelonia—Green Turtles

Chelonia mydas—Green Turtle
Chelonia m. mydas—Atlantic Green Turtle
Chelonia m. agassizi—Pacific Green Turtle

Chelydra—Snapping Turtles

Chelydra serpentina—Snapping Turtle
Chelydra s. serpentina—Common Snapping Turtle
Chelydra s. osceola—Florida Snapping Turtle

Chrysemys—Painted Turtles

Chrysemys picta—Painted Turtle
Chrysemys p. picta—Eastern Painted Turtle
Chrysemys p. belli—Western Painted Turtle
Chrysemys p. dorsalis—Southern Painted Turtle
Chrysemys p. marginata—Midland Painted Turtle

Clemmys—Pond Turtles

Clemmys guttata—Spotted Turtle
Clemmys insculpta—Wood Turtle
Clemmys marmorata—Western Pond Turtle
Clemmys m. marmorata—Northwestern Pond Turtle
Clemmys m. pallida—Southwestern Pond Turtle
Clemmys muhlenbergi—Bog Turtle

Deirochelys—Chicken Turtle

Deirochelys reticularia—Chicken Turtle

Dermochelys—Leatherback Turtles

Dermochelys coriacea—Leatherback
Dermochelys c. coriacea—Atlantic Leatherback
Dermochelys c. schlegeli—Pacific Leatherback

Emys—Semi-box Turtles

Emys blandingi—Blanding's Turtle

Eretmochelys—Hawksbill Turtles

Eretmochelys imbricata—Hawksbill
Eretmochelys i. imbricata—Atlantic Hawksbill
Eretmochelys i. squamata—Pacific Hawksbill

Gopherus—Gopher Tortoises

Gopherus agassizi—Desert Tortoise
Gopherus berlandieri—Texas Tortoise
Gopherus polyphemus—Gopher Tortoise

Graptemys—Map Turtles and Sawbacks

Graptemys barbouri—Barbour's Map Turtle
Graptemys flavimaculata—Yellow-blotched Sawback (Cagle, Tulane Stud. Zool., 1: 167)
Graptemys geographica—Map Turtle
Graptemys nigrinoda—Black-knobbed Sawback (Cagle, Tulane Stud. Zool., 1: 173)
Graptemys oculifera—Ringed Sawback
Graptemys pseudogeographica—False Map Turtle
Graptemys p. pseudogeographica—False Map Turtle
Graptemys p. kohni—Mississippi Map Turtle
Graptemys p. ouachitensis—Ouachita Map Turtle (Cagle, Occ. Pap. Mus. Zool., Univ. Michigan, 546: 10)
Graptemys p. sabinensis—Sabine Map Turtle (Cagle, Occ. Pap. Mus. Zool., Univ. Michigan, 546: 2)
Graptemys p. versa—Texas Map Turtle
Graptemys pulchra—Alabama Map Turtle

Kinosternon—Mud Turtles

Kinosternon bauri—Striped Mud Turtle
Kinosternon b. bauri—Key Mud Turtle
Kinosternon b. palmarum—Striped Mud Turtle (for use of names see Uzzell and Schwartz, Journ. Elisha Mitchell Sci. Soc., 71: 28–35)
Kinosternon flavescens—Yellow Mud Turtle
Kinosternon f. flavescens—Yellow Mud Turtle
Kinosternon f. spooneri—Illinois Mud Turtle
Kinosternon hirtipes—Mexican Mud Turtle
Kinosternon h. murrayi—Mexican Mud Turtle
Kinosternon sonoriense—Sonora Mud Turtle
Kinosternon subrubrum—Mud Turtle
Kinosternon s. subrubrum—Eastern Mud Turtle
Kinosternon s. hippocrepis—Mississippi Mud Turtle
Kinosternon s. steindachneri—Florida Mud Turtle

Lepidochelys—Ridleys

Lepidochelys olivacea—Ridley
Lepidochelys o. kempi—Atlantic Ridley
Lepidochelys o. remivaga—Pacific Ridley

Macrochelys—Alligator Snapping Turtles

Macrochelys temmincki—Alligator Snapping Turtle

Malaclemys—Diamondback Terrapins

Malaclemys terrapin—Diamondback Terrapin
Malaclemys t. terrapin—Northern Diamondback Terrapin
Malaclemys t. centrata—Carolina Diamondback Terrapin
Malaclemys t. littoralis—Texas Diamondback Terrapin
Malaclemys t. macrospilota—Ornate Diamondback Terrapin
Malaclemys t. pileata—Mississippi Diamondback Terrapin
Malaclemys t. rhizophorarum—Mangrove Terrapin
Malaclemys t. tequesta—Florida East Coast Terrapin (Schwartz, Proc. Biol. Soc. Washington, 68: 158)

Pseudemys—Cooters and Sliders

Pseudemys floridana—Cooter
Pseudemys f. floridana—Florida Cooter
Pseudemys f. concinna—River Cooter
Pseudemys f. hieroglyphica—Slider
Pseudemys f. hoyi—Missouri Slider
Pseudemys f. mobilensis—Mobile Cooter
Pseudemys f. peninsularis—Peninsula Cooter
Pseudemys f. suwanniensis—Suwannee Cooter
Pseudemys f. texana—Texas Slider
Pseudemys nelsoni—Florida Red-bellied Turtle
Pseudemys rubriventris—Red-bellied Turtle
Pseudemys r. rubriventris—Red-bellied Turtle
Pseudemys r. bangsi—Plymouth Turtle
Pseudemys scripta—Pond Slider
Pseudemys s. scripta—Yellow-bellied Turtle
Pseudemys s. elegans—Red-eared Turtle
Pseudemys s. gaigeae—Big Bend Turtle
Pseudemys s. troosti—Cumberland Turtle

Sternotherus—Musk Turtles

Sternotherus carinatus—Keel-backed Musk Turtle
Sternotherus c. carinatus—Razor-backed Musk Turtle
Sternotherus c. minor—Loggerhead Musk Turtle
Sternotherus c. peltifer—Stripe-necked Musk Turtle
Sternotherus depressus—Flattened Musk Turtle (Tinkle and Webb, Tulane Stud. Zool., 3: 53)
Sternotherus odoratus—Stinkpot

Terrapene—Box Turtles

Terrapene carolina—Box Turtle
Terrapene c. carolina—Eastern Box Turtle
Terrapene c. bauri—Florida Box Turtle
Terrapene c. major—Gulf Coast Box Turtle
Terrapene c. triunguis—Three-toed Box Turtle
Terrapene ornata—Western Box Turtle
Terrapene o. ornata—Ornate Box Turtle
Terrapene o. luteola—Salt Basin Box Turtle

Trionyx—Softshell Turtles

Trionyx ferox—Spiny Softshell
Trionyx f. ferox—Florida Softshell
Trionyx f. agassizi—Carolina Softshell
Trionyx f. aspera—Gulf Coast Softshell
Trionyx f. emoryi—Texas Softshell
Trionyx f. hartwegi—Western Spiny Softshell
Trionyx f. spinifera—Eastern Spiny Softshell
Trionyx muticus—Smooth Softshell

CROCODILIANS

Alligator—Alligators

Alligator mississipiensis—American Alligator

Crocodylus—Crocodiles

Crocodylus acutus—American Crocodile

LIZARDS

Anniella—Legless Lizards

Anniella pulchra—California Legless Lizard
Anniella p. pulchra—Silvery Legless Lizard
Anniella p. nigra—Black Legless Lizard

Anolis—Anoles

Anolis carolinensis—Green Anole
Anolis c. carolinensis—Carolina Anole
Anolis distichus—Bahaman Bark Anole
Anolis sagrei—Brown Anole
Anolis s. sagrei—Cuban Brown Anole
Anolis s. ordinatus—Bahaman Brown Anole
Anolis s. stejnegeri—Key West Anole

Callisaurus—Zebra-tailed Lizards

Callisaurus draconoides—Zebra-tailed Lizard
Callisaurus d. gabbi—Colorado Desert Zebra-tailed Lizard
Callisaurus d. myurus—Nevada Zebra-tailed Lizard
Callisaurus d. ventralis—Arizona Zebra-tailed Lizard

Cnemidophorus—Whiptails and Racerunner

Cnemidophorus hyperythrus—Orange - throated Whiptail
Cnemidophorus h. beldingi—Orange-throated Whiptail
Cnemidophorus inornatus—Little Striped Whiptail
Cnemidophorus neomexicanus—New Mexico Whiptail (Lowe & Zweifel, Bull. Chicago Acad. Sci., 9: 230)
Cnemidophorus perplexus—Devil's River Whiptail
Cnemidophorus sacki—Spotted Whiptail
Cnemidophorus s. gularis—Eastern Spotted Whiptail
Cnemidophorus s. innotatus—Plateau Whiptail (suppressed by Lowe, Breviora, 47: 1–3)
Cnemidophorus s. semifasciatus—Big Bend Whiptail
Cnemidophorus s. stictogrammus—Arizona Whiptail
Cnemidophorus s. xanthonotus—Red-backed Whiptail (Duellman & Lowe, Nat. Hist. Misc., 120: 2)
Cnemidophorus sexlineatus—Six-lined Racerunner
Cnemidophorus tessellatus—Checkered Whiptail
Cnemidophorus tigris—Western Whiptail
Cnemidophorus t. tigris—Great Basin Whiptail
Cnemidophorus t. aethiops—Black-breasted Whiptail (Duellman, Occ. Pap. Mus. Zool., Univ. Michigan, 569: 9)
Cnemidophorus t. gracilis—Southern Whiptail
Cnemidophorus t. marmoratus—Marbled Whiptail
Cnemidophorus t. multiscutatus—Coastal Whiptail

Cnemidophorus t. mundus—California Whiptail
Cnemidophorus t. septentrionalis—Northern Whiptail
Cnemidophorus velox—Plateau Whiptail (Lowe, Breviora, 47: 4)

Coleonyx—Banded Geckos

Coleonyx variegatus—Banded Gecko
Coleonyx v. variegatus—Desert Banded Gecko
Coleonyx v. abbotti—San Diego Banded Gecko
Coleonyx v. bogerti—Tucson Banded Gecko
Coleonyx v. brevis—Texas Banded Gecko
Coleonyx v. utahensis—Utah Banded Gecko

Crotaphytus—Collared and Leopard Lizards

Crotaphytus collaris—Collared Lizard
Crotaphytus c. collaris—Eastern Collared Lizard
Crotaphytus c. auriceps—Yellow-headed Collared Lizard
Crotaphytus c. baileyi—Western Collared Lizard
Crotaphytus reticulatus—Reticulate Collared Lizard
Crotaphytus wislizeni—Leopard Lizard
Crotaphytus w. wislizeni—Long-nosed Leopard Lizard
Crotaphytus w. silus—Blunt-nosed Leopard Lizard

Dipsosaurus—Desert Iguanas

Dipsosaurus dorsalis—Desert Iguana
Dipsosaurus d. dorsalis—Desert Iguana

Eumeces—Striped Skinks

Eumeces anthracinus—Coal Skink
Eumeces a. anthracinus—Northern Coal Skink
Eumeces a. pluvialis—Southern Coal Skink
Eumeces brevilineatus—Short-lined Skink
Eumeces callicephalus—Mountain Skink
Eumeces egregius—Florida Red-tailed Skink
Eumeces e. egregius—Striped Red-tailed Skink
Eumeces e. onocrepis—Brown Red-tailed Skink
Eumeces fasciatus—Five-lined Skink
Eumeces gaigei—Two-lined Skink
Eumeces gilberti—Gilbert's Skink
Eumeces g. gilberti—Greater Brown Skink
Eumeces g. arizonensis—Arizona Skink (Lowe & Shannon, Herpetologica, 10: 185)
Eumeces g. cancellosus—Variegated Skink
Eumeces g. placerensis—Northern Brown Skink
Eumeces g. rubricaudatus—Western Red-tailed Skink
Eumeces inexpectatus—Southeastern Five-lined Skink
Eumeces laticeps—Broad-headed Skink
Eumeces multivirgatus—Many-lined Skink
Eumeces obsoletus—Great Plains Skink
Eumeces septentrionalis—Prairie Skink
Eumeces s. septentrionalis—Northern Prairie Skink
Eumeces s. obtusirostris—Southern Prairie Skink
Eumeces s. pallidus—Edwards Plateau Skink
Eumeces skiltonianus—Western Skink
Eumeces taylori—Pecos Skink
Eumeces tetragrammus—Four-lined Skink

Gerrhonotus—Alligator Lizards

Gerrhonotus coeruleus—Northern Alligator Lizard
Gerrhonotus c. coeruleus—San Francisco Alligator Lizard
Gerrhonotus c. palmeri—Sierra Alligator Lizard
Gerrhonotus c. principis—Northern Alligator Lizard
Gerrhonotus c. shastensis—Shasta Alligator Lizard
Gerrhonotus c. utahensis—Utah Alligator Lizard (Woodbury, Proc. Biol. Soc. Washington, 58: 6)
Gerrhonotus kingi—Arizona Alligator Lizard
Gerrhonotus k. nobilis—Arizona Alligator Lizard (Tihen, Trans. Kansas Acad. Sci., 51: 300)
Gerrhonotus levicollis—Sierra Madre Alligator Lizard
Gerrhonotus l. levicollis—Sierra Madre Alligator Lizard
Gerrhonotus liocephalus—Texas Alligator Lizard
Gerrhonotus l. infernalis—Texas Alligator Lizard
Gerrhonotus multicarinatus—Southern Alligator Lizard
Gerrhonotus m. multicarinatus—California Alligator Lizard
Gerrhonotus m. scincicauda—Oregon Alligator Lizard
Gerrhonotus m. webbi—San Diego Alligator Lizard

Gonatodes—Padless Geckos

Gonatodes fuscus—Yellow-headed Gecko

Heloderma—Beaded Lizards

Heloderma suspectum—Gila Monster

Hemidactylus—House Geckos

Hemidactylus turcicus—Mediterranean Gecko
Hemidactylus t. turcicus—Mediterranean Gecko

Holbrookia—Earless Lizards

Holbrookia lacerata—Spot-tailed Earless Lizard
Holbrookia maculata—Lesser Earless Lizard
Holbrookia m. maculata—Northern Earless Lizard
Holbrookia m. approximans—Speckled Earless Lizard
Holbrookia m. elegans—Western Earléss Lizard
Holbrookia m. pulchra—Huachuca Earless Lizard
Holbrookia m. ruthveni—Bleached Earless Lizard
Holbrookia propinqua—Keeled Earless Lizard
Holbrookia texana—Greater Earless Lizard
Holbrookia t. texana—Texas Earless Lizard
Holbrookia t. scitula—Southwestern Earless Lizard

Leiocephalus—Curl-tailed Lizards

Leiocephalus carinatus—Bahaman Curl-tailed Lizard
Leiocephalus c. virescens—Green Cay Curl-tailed Lizard

Lygosoma—(no name proposed for the genus as a whole)

Scincella (subgenus)—Ground Skinks
Lygosoma laterale—Ground Skink

Neoseps—Sand Skink

Neoseps reynoldsi—Sand Skink

Ophisaurus—Glass Lizards

Ophisaurus attenuatus—Slender Glass Lizard
Ophisaurus a. attenuatus—Western Slender Glass Lizard
Ophisaurus a. longicaudus—Eastern Slender Glass Lizard
Ophisaurus compressus—Island Glass Lizard
Ophisaurus ventralis—Eastern Glass Lizard

Phrynosoma—Horned Lizards

Phrynosoma cornutum—Texas Horned Lizard
Phrynosoma coronatum—Coast Horned Lizard
Phrynosoma c. blainvillei—San Diego Horned Lizard
Phrynosoma c. frontale—California Horned Lizard
Phrynosoma douglassi—Short-horned Lizard
Phrynosoma d. douglassi—Pigmy Horned Lizard
Phrynosoma d. brevirostre—Eastern Short-horned Lizard
Phrynosoma d. hernandesi—Mountain Short-horned Lizard
Phrynosoma d. ornatissimum—Desert Short-horned Lizard
Phrynosoma d. ornatum—Salt Lake Horned Lizard
Phrynosoma m'calli—Flat-tailed Horned Lizard
Phrynosoma modestum—Round-tailed Horned Lizard
Phrynosoma platyrhinos—Desert Horned Lizard
Phrynosoma p. platyrhinos—Northern Desert Horned Lizard
Phrynosoma p. calidiarum—Southern Desert Horned Lizard
Phrynosoma solare—Regal Horned Lizard

Phyllodactylus—Leaf-toed Geckos

Phyllodactylus tuberculosus—Leaf-toed Gecko

Rhineura—Worm Lizards

Rhineura floridana—Worm Lizard

Sauromalus—Chuckwallas

Sauromalus obesus—Chuckwalla
Sauromalus o. obesus—Western Chuckwalla
Sauromalus o. tumidus—Arizona Chuckwalla

Sceloporus—Spiny Lizards

Sceloporus clarki—Clark's Spiny Lizard
Sceloporus c. clarki—Sonora Spiny Lizard
Sceloporus c. vallaris—Plateau Spiny Lizard (Shannon and Urbano, Herpetologica, 10: 189)
Sceloporus cyanogenys—Blue Spiny Lizard
Sceloporus graciosus—Sagebrush Lizard
Sceloporus g. graciosus—Great Basin Sagebrush Lizard
Sceloporus g. gracilis—Northwestern Sagebrush Lizard
Sceloporus g. vandenburgianus—Southern Sagebrush Lizard
Sceloporus grammicus—Mesquite Lizard
Sceloporus g. disparilis—Mesquite Lizard
Sceloporus jarrovi—Yarrow's Spiny Lizard
Sceloporus j. jarrovi—Yarrow's Spiny Lizard
Sceloporus magister—Desert Spiny Lizard
Sceloporus m. magister—Desert Spiny Lizard
Sceloporus m. bimaculosus—Twin-spotted Spiny Lizard (Phelan and Brattstrom, Herpetologica, 11: 9)
Sceloporus m. transversus—Barred Spiny Lizard (Phelan and Brattstrom, Herpetologica, 11: 10)
Sceloporus m. uniformis—Yellow-backed Spiny Lizard (Phelan and Brattstrom, Herpetologica, 11: 7)
Sceloporus merriami—Canyon Lizard
Sceloporus m. merriami—Merriam's Canyon Lizard
Sceloporus m. annulatus—Big Bend Canyon Lizard
Sceloporus occidentalis—Western Fence Lizard
Sceloporus o. occidentalis—Northwestern Fence Lizard
Sceloporus o. becki—Island Fence Lizard
Sceloporus o. biseriatus—San Joaquin Fence Lizard
Sceloporus o. bocourti—Coast Range Fence Lizard (Bell, Herpetologica, 10: 35)
Sceloporus o. longipes—Great Basin Fence Lizard (Bell, Herpetologica, 10: 33)
Sceloporus o. taylori—Sierra Fence Lizard
Sceloporus olivaceus—Texas Spiny Lizard
Sceloporus orcutti—Granite Spiny Lizard
Sceloporus poinsetti—Crevice Spiny Lizard
Sceloporus scalaris—Bunch Grass Lizard
Sceloporus s. slevini—Bunch Grass Lizard
Sceloporus undulatus—Eastern Fence Lizard
Sceloporus u. undulatus—Southern Fence Lizard
Sceloporus u. consobrinus—Southern Prairie Lizard
Sceloporus u. elongatus—Northern Plateau Lizard
Sceloporus u. garmani—Northern Prairie Lizard
Sceloporus u. hyacinthinus—Northern Fence Lizard
Sceloporus u. tristichus—Southern Plateau Lizard
Sceloporus u. virgatus—Striped Plateau Lizard
Sceloporus variabilis—Rose-bellied Lizard
Sceloporus v. marmoratus—Texas Rose-bellied Lizard
Sceloporus woodi—Florida Scrub Lizard

Sphaerodactylus—Dwarf Geckos

Sphaerodactylus argus argus—Ocellated Gecko (Savage, Trans. Kansas Acad. Sci., 57: 328)
Sphaerodactylus cinereus—Ashy Gecko
Sphaerodactylus notatus—Reef Gecko

Uma—Fringe-toed Lizards

Uma notata—Fringe-toed Lizard
Uma n. notata—Colorado Desert Fringe-toed Lizard
Uma n. inornata—Coachella Valley Fringe-toed Lizard
Uma n. scoparia—Mojave Fringe-toed Lizard

Uta—Utas

Uta graciosa—Long-tailed Brush Lizard
Uta g. graciosa—Western Brush Lizard (Lowe, Herpetologica, 11: 97)
Uta g. shannoni—Arizona Brush Lizard (Lowe, Herpetologica, 11: 97—described as a *Urosaurus*)
Uta mearnsi—Banded Rock Lizard
Uta microscutata—Small-scaled Lizard
Uta ornata—Tree Lizard
Uta o. ornata—Eastern Tree Lizard
Uta o. chiricahuae—Chiricahua Tree Lizard (suppressed by Murray, Herpetologica, 9: 112)
Uta o. levis—Smooth Tree Lizard
Uta o. linearis—Lined Tree Lizard
Uta o. schmidti—Big Bend Tree Lizard
Uta o. symmetrica—Colorado River Tree Lizard
Uta o. wrighti—Northern Tree Lizard
Uta stansburiana—Side-blotched Lizard
Uta s. stansburiana—Northern Side-blotched Lizard
Uta s. hesperis—California Side-blotched Lizard
Uta s. stejnegeri—Desert Side-blotched Lizard

NOTE—Although it is not the function of this Committee to rule on taxonomic matters, we are aware that certain herpetologists would partition the genus *Uta*, and one of us (Lowe) has recently described a new form under the generic name of *Urosaurus* (Herpetologica, 11: 97). A scheme for the division of *Uta* into four genera has been presented by Mittleman (Bull. Mus. Comp. Zool., 41: 107–117). For those

who would partition *Uta*, Lowe suggests the following common names at the generic level: *Petrosaurus* = Rock Lizards; *Urosaurus* = Tree Lizards; *Uta* = Side-blotched Lizards.

Xantusia—Night Lizards

Xantusia arizonae—Arizona Night Lizard
Xantusia henshawi—Granite Night Lizard
Xantusia riversiana—Island Night Lizard
Xantusia vigilis—Desert Night Lizard
Xantusia v. vigilis—Desert Night Lizard (Savage, Amer. Midl. Nat., 48: 477)

SNAKES

Abastor—Rainbow Snake

Abastor erythrogrammus—Rainbow Snake

Ancistrodon—Copperheads and Cottonmouths

Ancistrodon contortrix—Copperhead
Ancistrodon c. contortrix—Southern Copperhead
Ancistrodon c. laticinctus—Broad-banded Copperhead
Ancistrodon c. mokeson—Northern Copperhead
Ancistrodon c. pictigaster—Trans-Pecos Copperhead
Ancistrodon piscivorus—Cottonmouth
Ancistrodon p. piscivorus—Eastern Cottonmouth
Ancistrodon p. leucostoma—Western Cottonmouth

Arizona—Glossy Snakes

Arizona elegans—Glossy Snake
Arizona e. elegans—Texas Glossy Snake
Arizona e. blanchardi—Kansas Glossy Snake
Arizona e. candida—Mojave Glossy Snake
Arizona e. eburnata—Desert Glossy Snake
Arizona e. noctivaga—Arizona Glossy Snake
Arizona e. occidentalis—California Glossy Snake
Arizona e. philipi—Painted Desert Glossy Snake

Carphophis—Worm Snakes

Carphophis amoenus—Worm Snake
Carphophis a. amoenus—Eastern Worm Snake
Carphophis a. helenae—Midwest Worm Snake
Carphophis a. vermis—Western Worm Snake

Cemophora—Scarlet Snake

Cemophora coccinea—Scarlet Snake

Charina—Rubber Boas

Charina bottae—Rubber Boa
Charina b. bottae—Pacific Rubber Boa
Charina b. umbratica—Southern Rubber Boa
Charina b. utahensis—Rocky Mountain Rubber Boa

Chilomeniscus—Sand Snakes

Chilomeniscus cinctus—Banded Sand Snake

Chionactis—Shovel-nosed Snakes

Chionactis occipitalis—Western Shovel-nosed Snake
Chionactis o. occipitalis—Mojave Shovel-nosed Snake
Chionactis o. annulata—Colorado Desert Shovel-nosed Snake
Chionactis o. klauberi—Tucson Shovel-nosed Snake
Chionactis o. talpina—Nevada Shovel-nosed Snake
Chionactis palarostris—Sonora Shovel-nosed Snake
Chionactis p. organica—Organ Pipe Shovel-nosed Snake

Coluber—Racers

Coluber constrictor—Racer
Coluber c. constrictor—Northern Black Racer
Coluber c. anthicus—Buttermilk Snake
Coluber c. flaviventris—Eastern Yellow-bellied Racer
Coluber c. foxi—Blue Racer (suppressed by Auffenberg, Tulane Stud. Zool., 2: 92)
Coluber c. helvigularis—Brown-chinned Racer (Auffenberg, Tulane Stud. Zool., 2: 105)
Coluber c. mormon—Western Yellow-bellied Racer
Coluber c. paludicola—Everglades Racer (Auffenberg & Babbitt, Copeia, 1953: 44)
Coluber c. priapus—Southern Black Racer
Coluber c. stejnegerianus—Rio Grande Racer

Coniophanes—Black-striped Snakes

Coniophanes imperialis—Black-striped Snake
Coniophanes i. imperialis—Black-striped Snake

Contia—Sharp-tailed Snake

Contia tenuis—Sharp-tailed Snake

Crotalus—Rattlesnakes

Crotalus adamanteus—Eastern Diamondback Rattlesnake
Crotalus atrox—Western Diamondback Rattlesnake
Crotalus cerastes—Sidewinder
Crotalus c. cerastes—Mojave Desert Sidewinder
Crotalus c. cercobombus—Sonora Sidewinder (Savage & Cliff, Nat. Hist. Misc., 119: 2)
Crotalus c. laterorepens—Colorado Desert Sidewinder
Crotalus horridus—Timber Rattlesnake
Crotalus h. horridus—Timber Rattlesnake
Crotalus h. atricaudatus—Canebrake Rattlesnake
Crotalus lepidus—Rock Rattlesnake
Crotalus l. lepidus—Mottled Rock Rattlesnake
Crotalus l. klauberi—Banded Rock Rattlesnake
Crotalus mitchelli—Speckled Rattlesnake
Crotalus m. pyrrhus—Southwestern Speckled Rattlesnake
Crotalus m. stephensi—Panamint Rattlesnake
Crotalus molossus—Black-tailed Rattlesnake
Crotalus m. molossus—Northern Black-tailed Rattlesnake
Crotalus pricei—Twin-spotted Rattlesnake
Crotalus p. pricei—Twin-spotted Rattlesnake
Crotalus ruber—Red Diamond Rattlesnake
Crotalus r. ruber—Red Diamond Rattlesnake
Crotalus scutulatus—Mojave Rattlesnake
Crotalus s. scutulatus—Mojave Rattlesnake
Crotalus tigris—Tiger Rattlesnake
Crotalus viridis—Western Rattlesnake
Crotalus v. viridis—Prairie Rattlesnake
Crotalus v. abyssus—Grand Canyon Rattlesnake
Crotalus v. cerberus—Arizona Black Rattlesnake
Crotalus v. decolor—Midget Faded Rattlesnake
Crotalus v. helleri—Southern Pacific Rattlesnake
Crotalus v. lutosus—Great Basin Rattlesnake
Crotalus v. nuntius—Hopi Rattlesnake
Crotalus v. oreganus—Northern Pacific Rattlesnake
Crotalus willardi—Ridge-nosed Rattlesnake
Crotalus w. willardi—Arizona Ridge-nosed Rattlesnake

Diadophis—Ringneck Snakes

Diadophis amabilis—Western Ringneck Snake
Diadophis a. amabilis—Pacific Ringneck Snake
Diadophis a. modestus—San Bernardino Ringneck Snake
Diadophis a. occidentalis—Northwestern Ringneck Snake
Diadophis a. pulchellus—Coral-bellied Ringneck Snake
Diadophis a. similis—San Diego Ringneck Snake
Diadophis a. vandenburghi—Monterey Ringneck Snake
Diadophis punctatus—Eastern Ringneck Snake
Diadophis p. punctatus—Southern Ringneck Snake
Diadophis p. arnyi—Prairie Ringneck Snake
Diadophis p. docilis—Texas Ringneck Snake
Diadophis p. edwardsi—Northern Ringneck Snake
Diadophis p. stictogenys—Mississippi Ringneck Snake
Diadophis regalis—Regal Ringneck Snake
Diadophis r. regalis—Regal Ringneck Snake
Diadophis r. blanchardi—Big Bend Ringneck Snake

Drymarchon—Indigo Snakes

Drymarchon corais—Indigo Snake
Drymarchon c. couperi—Eastern Indigo Snake
Drymarchon c. erebennus—Texas Indigo Snake

Drymobius—Speckled Racers

Drymobius margaritiferus—Speckled Racer
Drymobius m. margaritiferus—Speckled Racer

Elaphe—Rat Snakes

Elaphe guttata—Corn Snake
Elaphe g. guttata—Corn Snake
Elaphe g. emoryi—Great Plains Rat Snake
Elaphe g. rosacea—Rosy Rat Snake
Elaphe obsoleta—Rat Snake
Elaphe o. obsoleta—Black Rat Snake
Elaphe o. bairdi—Baird's Rat Snake
Elaphe o. deckerti—Key Rat Snake (Neill, Publ. Res. Div., Ross Allen's Rept. Inst., 1: 89)
Elaphe o. lindheimeri—Texas Rat Snake
Elaphe o. quadrivittata—Yellow Rat Snake
Elaphe o. rossalleni—Everglades Rat Snake (Neill, Publ. Res. Div., Ross Allen's Rept. Inst., 1: 89)
Elaphe o. spiloides—Gray Rat Snake
Elaphe o. williamsi—Gulf Hammock Rat Snake (Neill, Publ. Res. Div., Ross Allen's Rept. Inst., 1: 89)
Elaphe subocularis—Trans-Pecos Rat Snake
Elaphe triaspis—Green Rat Snake
Elaphe t. intermedia—Green Rat Snake
Elaphe vulpina—Fox Snake
Elaphe v. vulpina—Western Fox Snake
Elaphe v. gloydi—Eastern Fox Snake

Farancia—Mud Snakes

Farancia abacura—Mud Snake
Farancia a. abacura—Eastern Mud Snake
Farancia a. reinwardti—Western Mud Snake

Ficimia—Hook-nosed Snakes

Ficimia cana—Western Hook-nosed Snake
Ficimia olivacea—Mexican Hook-nosed Snake
Ficimia o. streckeri—Mexican Hook-nosed Snake

Haldea—Earth Snakes

Haldea striatula—Rough Earth Snake
Haldea valeriae—Smooth Earth Snake
Haldea v. valeriae—Eastern Earth Snake
Haldea v. elegans—Western Earth Snake
Haldea v. pulchra—Mountain Earth Snake (Richmond, Ann. Carnegie Mus., 33: 251)

Heterodon—Hognose Snakes

Heterodon nasicus—Western Hognose Snake
Heterodon n. nasicus—Plains Hognose Snake
Heterodon n. gloydi—Dusty Hognose Snake (Edgren, Nat. Hist. Misc., 112: 3)
Heterodon n. kennerlyi—Mexican Hognose Snake
Heterodon platyrhinos—Eastern Hognose Snake
Heterodon p. platyrhinos—Eastern Hognose Snake
Heterodon p. browni—South Florida Hognose Snake (suppressed by Edgren, Nat. Hist. Misc., 112: 2)
Heterodon simus—Southern Hognose Snake

Hypsiglena—Night Snakes

Hypsiglena torquata—Night Snake
Hypsiglena t. deserticola—Desert Night Snake
Hypsiglena t. klauberi—San Diego Night Snake
Hypsiglena t. loreala—Mesa Verde Night Snake
Hypsiglena t. nuchalata—California Night Snake
Hypsiglena t. ochrorhyncha—Spotted Night Snake
Hypsiglena t. texana—Texas Night Snake

Lampropeltis—Kingsnakes

Lampropeltis alterna—Davis Mountain Kingsnake
Lampropeltis blairi—Trans-Pecos Kingsnake
Lampropeltis calligaster—Prairie Kingsnake
Lampropeltis c. calligaster—Prairie Kingsnake
Lampropeltis c. rhombomaculata—Mole Snake
Lampropeltis doliata—Milk Snake
Lampropeltis d. doliata—Scarlet Kingsnake
Lampropeltis d. amaura—Louisiana Milk Snake
Lampropeltis d. annulata—Mexican Milk Snake
Lampropeltis d. gentilis—Western Milk Snake
Lampropeltis d. syspila—Red Milk Snake
Lampropeltis d. temporalis—Coastal Plain Milk Snake
Lampropeltis d. triangulum—Eastern Milk Snake
Lampropeltis getulus—Common Kingsnake
Lampropeltis g. getulus—Eastern Kingsnake
Lampropeltis g. brooksi—South Florida Kingsnake
Lampropeltis g. californiae—California Kingsnake
Lampropeltis g. floridana—Florida Kingsnake
Lampropeltis g. goini—Blotched Kingsnake
Lampropeltis g. holbrooki—Speckled Kingsnake
Lampropeltis g. niger—Black Kingsnake
Lampropeltis g. splendida—Sonora Kingsnake
Lampropeltis g. yumensis—Yuma Kingsnake
Lampropeltis pyromelana—Sonora Mountain Kingsnake
Lampropeltis p. pyromelana—Arizona Mountain Kingsnake (Tanner, Great Basin Nat., 13: 52)
Lampropeltis p. infralabialis—Utah Mountain Kingsnake (Tanner, Great Basin Nat., 13: 56)
Lampropeltis p. woodini—Huachuca Mountain Kingsnake (Tanner, Great Basin Nat., 13: 54)
Lampropeltis zonata—California Mountain Kingsnake
Lampropeltis z. zonata—Saint Helena Mountain Kingsnake
Lampropeltis z. multicincta—Sierra Mountain Kingsnake
Lampropeltis z. multifasciata—Coast Mountain Kingsnake (Zweifel, Copeia, 1952: 159)
Lampropeltis z. parvirubra—San Bernardino Mountain Kingsnake (Zweifel, Copeia, 1952: 160)
Lampropeltis z. pulchra—San Diego Mountain Kingsnake (Zweifel, Copeia, 1952: 162)

Leptodeira—Cat-eyed Snakes

Leptodeira annulata—Cat-eyed Snake
Leptodeira a. septentrionalis—Texas Cat-eyed Snake

Leptotyphlops—Slender Blind Snakes

Leptotyphlops dulcis—Texas Blind Snake
Leptotyphlops d. dulcis—Plains Blind Snake
Leptotyphlops d. dissecta—New Mexico Blind Snake
Leptotyphlops humilis—Western Blind Snake
Leptotyphlops h. humilis—Southwestern Blind Snake
Leptotyphlops h. cahuilae—Desert Blind Snake
Leptotyphlops h. segregus—Trans-Pecos Blind Snake
Leptotyphlops h. utahensis—Utah Blind Snake

Lichanura—Rosy Boas

Lichanura roseofusca—Rosy Boa
Lichanura r. roseofusca—Coastal Rosy Boa
Lichanura r. gracia—Desert Rosy Boa

Liodytes—Swamp Snakes

Liodytes alleni—Striped Swamp Snake
Liodytes a. alleni—Striped Swamp Snake
Liodytes a. lineapiatus—Everglades Swamp Snake

Masticophis—Whipsnakes

Masticophis bilineatus—Sonora Whipsnake
Masticophis b. bilineatus—Sonora Whipsnake (Hensley, Trans. Kansas Acad. Sci., 53: 272)
Masticophis b. lineolatus—Ajo Mountain Whipsnake (Hensley, Trans. Kansas Acad. Sci., 53: 272)
Masticophis flagellum—Coachwhip
Masticophis f. flagellum—Eastern Coachwhip
Masticophis f. cingulum—Banded Red Racer (Lowe & Woodin, Proc. Biol. Soc. Wash., 67: 247)
Masticophis f. flavigularis—Western Coachwhip (Maslin, Herpetologica, 9: 198)
Masticophis f. lineatulus—Lined Whipsnake
Masticophis f. piceus—Red Racer, Western Black Racer (for the two color phases)
Masticophis f. ruddocki—San Joaquin Whipsnake (Brattstrom & Warren, Herpetologica, 9: 177)
Masticophis f. testaceus—Pink Coachwhip (Maslin, Herpetologica, 9: 198)
Masticophis lateralis—Striped Racer
Masticophis l. lateralis—California Striped Racer (Riemer, Copeia, 1954: 46)
Masticophis l. euryxanthus—Alameda Striped Racer (Riemer, Copeia, 1954: 45)
Masticophis taeniatus—Striped Whipsnake
Masticophis t. taeniatus—Desert Striped Whipsnake
Masticophis t. ornatus—Central Texas Whipsnake
Masticophis t. ruthveni—Ruthven's Whipsnake
Masticophis t. schotti—Schott's Whipsnake

Micruroides—Western Coral Snake

Micruroides euryxanthus—Arizona Coral Snake

Micrurus—Eastern Coral Snakes

Micrurus fulvius—Eastern Coral Snake
Micrurus f. fulvius—Eastern Coral Snake
Micrurus f. barbouri—South Florida Coral Snake
Micrurus f. tenere—Texas Coral Snake

Natrix—Water Snakes

Natrix cyclopion—Green Water Snake
Natrix c. cyclopion—Green Water Snake
Natrix c. floridana—Florida Green Water Snake
Natrix erythrogaster—Plain-bellied Water Snake
Natrix e. erythrogaster—Red-bellied Water Snake
Natrix e. flavigaster—Yellow-bellied Water Snake
Natrix e. neglecta—Northern Copperbelly
Natrix e. transversa—Blotched Water Snake
Natrix grahami—Graham's Water Snake
Natrix harteri—Brazos Water Snake
Natrix kirtlandi—Kirtland's Water Snake
Natrix rhombifera—Diamond-backed Water Snake
Natrix r. rhombifera—Diamond-backed Water Snake
Natrix rigida—Glossy Water Snake
Natrix septemvittata—Queen Snake
Natrix sipedon—Common Water Snake
Natrix s. sipedon—Northern Water Snake
Natrix s. clarki—Gulf Salt Marsh Snake
Natrix s. compressicauda—Mangrove Water Snake
Natrix s. confluens—Broad-banded Water Snake
Natrix s. engelsi—Carteret Water Snake
Natrix s. fasciata—Banded Water Snake
Natrix s. insularum—Lake Erie Water Snake
Natrix s. pictiventris—Florida Water Snake
Natrix s. pleuralis—Midland Water Snake
Natrix s. taeniata—Atlantic Salt Marsh Snake
Natrix taxispilota—Brown Water Snake

Opheodrys—Green Snakes

Opheodrys aestivus—Rough Green Snake
Opheodrys a. aestivus—Eastern Rough Green Snake (Burger, Bull. Ecol. Soc. Amer., 28: 54)
Opheodrys a. majalis—Western Rough Green Snake (Burger, Bull. Ecol. Soc. Amer., 28: 54)
Opheodrys vernalis—Smooth Green Snake
Opheodrys v. vernalis—Eastern Smooth Green Snake
Opheodrys v. blanchardi—Western Smooth Green Snake

Oxybelis—Vine Snakes

Oxybelis aeneus—Vine Snake
Oxybelis a. auratus—Mexican Vine Snake

Phyllorhynchus—Leaf-nosed Snakes

Phyllorhynchus browni—Saddled Leaf-nosed Snake
Phyllorhynchus b. browni—Pima Leaf-nosed Snake
Phyllorhynchus b. lucidus—Maricopa Leaf-nosed Snake
Phyllorhynchus decurtatus—Spotted Leaf-nosed Snake
Phyllorhynchus d. nubilus—Clouded Leaf-nosed Snake
Phyllorhynchus d. perkinsi—Western Leaf-nosed Snake

Pituophis—Bullsnakes

Pituophis catenifer—Gopher Snake
Pituophis c. catenifer—Pacific Gopher Snake
Pituophis c. affinis—Sonora Gopher Snake
Pituophis c. annectens—San Diego Gopher Snake
Pituophis c. deserticola—Great Basin Gopher Snake
Pituophis c. pumilus—Santa Cruz Island Gopher Snake
Pituophis c. sayi—Bullsnake
Pituophis melanoleucus—Pine Snake
Pituophis m. melanoleucus—Northern Pine Snake
Pituophis m. lodingi—Black Pine Snake
Pituophis m. mugitus—Florida Pine Snake
Pituophis m. ruthveni—Louisiana Pine Snake

Rhadinaea—Slender Snakes

Rhadinaea flavilata—Yellow-lipped Snake

Rhinocheilus—Long-nosed Snakes

Rhinocheilus lecontei—Long-nosed Snake
Rhinocheilus l. lecontei—Western Long-nosed Snake
Rhinocheilus l. clarus—Desert Long-nosed Snake
Rhinocheilus l. tessellatus—Texas Long-nosed Snake

Salvadora—Patch-nosed Snakes

Salvadora grahamiae—Mountain Patch-nosed Snake
Salvadora hexalepis—Western Patch-nosed Snake
Salvadora h. hexalepis—Desert Patch-nosed Snake
Salvadora h. deserticola—Big Bend Patch-nosed Snake
Salvadora h. mojavensis—Mojave Patch-nosed Snake (Bogert, Amer. Mus. Nov., 1285: 6)
Salvadora h. virgultea—Coast Patch-nosed Snake
Salvadora lineata—Texas Patch-nosed Snake

Seminatrix—Black Swamp Snakes

Seminatrix pygaea—Black Swamp Snake
Seminatrix p. pygaea—North Florida Swamp Snake
Seminatrix p. cyclas—South Florida Swamp Snake
Seminatrix p. paludis—Carolina Swamp Snake

Sistrurus—Pigmy Rattlers and Massasaugas

Sistrurus catenatus—Massasauga
Sistrurus c. catenatus—Eastern Massasauga
Sistrurus c. edwardsi—Desert Massasauga (Gloyd, Bull. Chicago Acad. Sci., 10: 84)
Sistrurus c. tergeminus—Western Massasauga
Sistrurus miliarius—Pigmy Rattlesnake
Sistrurus m. miliarius—Carolina Pigmy Rattlesnake
Sistrurus m. barbouri—Dusky Pigmy Rattlesnake
Sistrurus m. streckeri—Western Pigmy Rattlesnake

Sonora—Ground Snakes

Sonora episcopa—Ground Snake
Sonora e. episcopa—Great Plains Ground Snake
Sonora e. taylori—South Texas Ground Snake
Sonora semiannulata—Western Ground Snake
Sonora s. semiannulata—Santa Rita Ground Snake
Sonora s. blanchardi—Trans-Pecos Ground Snake
Sonora s. gloydi—Grand Canyon Ground Snake
Sonora s. isozona—Great Basin Ground Snake
Sonora s. linearis—Vermilion-lined Ground Snake

Stilosoma—Short-tailed Snake

Stilosoma extenuatum—Short-tailed Snake

Storeria—Brown Snakes

Storeria dekayi—Brown Snake
Storeria d. dekayi—Northern Brown Snake
Storeria d. texana—Texas Brown Snake
Storeria d. victa—Florida Brown Snake
Storeria d. wrightorum—Midland Brown Snake
Storeria occipitomaculata—Red-bellied Snake
Storeria o. occipitomaculata—Northern Red-bellied Snake
Storeria o. obscura—Florida Red-bellied Snake

Tantilla—Black-headed Snakes

Tantilla atriceps—Mexican Black-headed Snake
Tantilla coronata—Crowned Snake
Tantilla c. coronata—Southeastern Crowned Snake
Tantilla c. mitrifer—Appalachian Crowned Snake (Schwartz, Herpetologica, 9: 153)
Tantilla c. wagneri—Florida Crowned Snake
Tantilla eiseni—Western Black-headed Snake
Tantilla e. eiseni—California Black-headed Snake
Tantilla e. transmontana—Desert Black-headed Snake
Tantilla gracilis—Flat-headed Snake
Tantilla g. gracilis—Slender Flat-headed Snake
Tantilla g. hallowelli—Northern Flat-headed Snake
Tantilla nigriceps—Plains Black-headed Snake
Tantilla n. nigriceps—Plains Black-headed Snake
Tantilla n. fumiceps—Texas Black-headed Snake
Tantilla utahensis—Utah Black-headed Snake
Tantilla wilcoxi—Huachuca Black-headed Snake

Thamnophis—Garter Snakes

Thamnophis angustirostris—Narrow-headed Garter Snake
Thamnophis brachystoma—Short-headed Garter Snake
Thamnophis butleri—Butler's Garter Snake
Thamnophis cyrtopsis—Black-necked Garter Snake
Thamnophis c. cyrtopsis—Western Black-necked Garter Snake
Thamnophis c. ocellata—Eastern Black-necked Garter Snake (Milstead, Texas Journ. Sci., 5: 373)
Thamnophis elegans—Western Garter Snake
Thamnophis e. elegans—Mountain Garter Snake
Thamnophis e. aquaticus—Aquatic Garter Snake
Thamnophis e. atratus—Santa Cruz Garter Snake
Thamnophis e. biscutatus—Klamath Garter Snake
Thamnophis e. couchi—Sierra Garter Snake
Thamnophis e. gigas—Giant Garter Snake
Thamnophis e. hammondi—Two-striped Garter Snake
Thamnophis e. hydrophila—Oregon Garter Snake
Thamnophis e. nigrescens—Puget Sound Garter Snake
Thamnophis e. terrestris—Coast Garter Snake
Thamnophis e. vagrans—Wandering Garter Snake
Thamnophis eques—Mexican Garter Snake
Thamnophis e. megalops—Mexican Garter Snake
Thamnophis marcianus—Checkered Garter Snake
Thamnophis m. marcianus—Eastern Checkered Garter Snake
Thamnophis m. nigrolateris—Western Checkered Garter Snake
Thamnophis ordinoides—Northwestern Garter Snake
Thamnophis radix—Plains Garter Snake
Thamnophis r. radix—Eastern Plains Garter Snake
Thamnophis r. haydeni—Western Plains Garter Snake
Thamnophis sauritus—Ribbon Snake
Thamnophis s. sauritus—Eastern Ribbon Snake
Thamnophis s. proximus—Western Ribbon Snake
Thamnophis s. sackeni—Southern Ribbon Snake
Thamnophis sirtalis—Common Garter Snake
Thamnophis s. sirtalis—Eastern Garter Snake
Thamnophis s. annectens—Texas Garter Snake (Brown, Annot. Check List Repts. & Amphs. Texas: 1950, 203)
Thamnophis s. concinnus—Red-spotted Garter Snake
Thamnophis s. fitchi—Valley Garter Snake
Thamnophis s. infernalis—California Red-sided Garter Snake

Thamnophis s. parietalis—Red-sided Garter Snake
Thamnophis s. pickeringi—Puget Sound Red-sided Garter Snake
Thamnophis s. tetrataenia—San Francisco Garter Snake
Thamnophis s. trilineata—Vancouver Garter Snake

Trimorphodon—Lyre Snakes

Trimorphodon lambda—Sonora Lyre Snake
Trimorphodon vandenburghi—California Lyre Snake
Trimorphodon vilkinsoni—Texas Lyre Snake

Tropidoclonion—Lined Snakes

Tropidoclonion lineatum—Lined Snake
Tropidoclonion l. lineatum—Northern Lined Snake (Ramsey, Herpetologica, 9: 9)
Tropidoclonion l. annectens—Central Lined Snake (Ramsey, Herpetologica, 9: 12)
Tropidoclonion l. texanum—Texas Lined Snake (Ramsey, Herpetologica, 9: 14)

Herpetological Notes

DESCRIPTION OF A NEW SUBSPECIES OF THE BOID SNAKE, *ENYGRUS CARINATUS*.—Specimens of *Enygrus carinatus* from the Solomon and Santa Cruz islands appear to be distinct from the typical form as it exists elsewhere. Typical *carinatus* is found in the Trobriand Islands, D'Entrecasteaux Islands, Woodlark Island, the Bismarck Archipelago, Louisiade Archipelago, Sangir Islands, Telauer Islands, Pelew Islands, and Molucca Islands; and on the islands of New Guinea, Ansus, Jobi, Misore, Batanta, Salawatti, Timor Laut, Celebes, and possibly Java.

I am naming the new form in honor of Mr. John Paulson, of Gothenburg, the Swedish herpetologist who has been particularly interested in snakes of the family Boidae for many years, and has collected them and studied their habits in many parts of the world.

Enygrus carinatus paulsoni, *subsp. nov.*

TYPE.—Museum of Comparative Zoology, Harvard University, No. 14521.

TYPE LOCALITY.—Ugi Island, Solomon Islands.

PARATYPES.—Mus. Comp. Zool., Harvard Univ., Nos. 14522–8, 14530–2; Chicago Nat. Hist. Mus., No. 13704. M. C. Z., No. 14502, Tulakora, Ysabel Island, Solomon Is.; M. C. Z. No. 14505, Bio Island, Solomon Is.; M. C. Z. Nos. 14506–12, Auki, Malaita Island, Solomon Is.; Amer. Mus. Nat. Hist., No. 42214, Santa Ana, Solomon Is.; Chicago Nat. Hist. Mus., Nos. 13802–4, Tunnibuli, Ysabel Island, Solomon Is.; Univ. Mich. Mus. Zool., Nos. 99982–4, Florida Island, Solomon Is.; Univ. Mich. Mus. Zool., Nos. 99976–7, 99981, and 99985–6, Tulagi, Florida Island, Solomon Is.

DIAGNOSIS.—This form may be distinguished from the related subspecies *Enygrus carinatus carinatus* by the higher average number of scale rows (35–47, average 39.8, instead of 31–39, average 35.8), by the higher average number of ventrals (179–216, average 192.7, instead of 163–196, average 178.7), and by the color pattern, consisting in *paulsoni* of a dark zigzag or jagged middorsal streak and smaller irregular lateral and ventral spots on a light ground, and in *carinatus* of a series of dorsal spots, which may be dark and distinct, indistinct, or entirely lacking, or fused into a dorsal stripe which is, however, rarely jagged.

DESCRIPTION OF TYPE.—Male. Squamation: scale rows 31–39–25, heavily keeled above, less heavily keeled on the sides, and with the four most ventral rows on each side smooth; ventrals 199; caudals 46; supralabials 11, with the 6th and 7th reaching the eye; infralabials 14 on the right side, 13 on the left; ocular ring with 9 scales on the right side, 10 on the left; nasals divided and separated by 3 scales. Anal spurs present.

Coloration: ground color pale with a dark jagged mid-dorsal streak; sides and belly lighter and irregularly spotted with numerous small dark spots.

Dentition: mandibular teeth 25; maxillary 29; palatine 10; and pterygoid 22.

The specimen measures 567 mm., with a body length of 485 mm. and a tail length of 82 mm. or 14.4 per cent of the total length.

VARIATION.—The variation in scale counts, tail length, and teeth found in the type and paratypes of this subspecies may be summarized as follows: scale rows at neck 29–39, average 33.7; at midbody 35–47, average 40.6; anterior to the vent 23–29, average 26.6; ventrals 181–199, average 189.8; caudals 40–50, average 44.1; sum of ventrals and caudals 222–246, average 233.9; supralabials 11–15, average 12.6; infralabials 12–18, average 14.1; oculars 8–14, average 10.5; usually 2, rarely 3, labials reach the orbit (most often the sixth and seventh, but frequently the seventh and eighth, and occasionally the fifth and sixth, or sixth, seventh and eighth); 3 to 5 smooth scale rows adjacent to the ventrals on each side (usually 4 or 5, rarely 3); tail

length forming from .108 to .159 of the total length (average .139), with the longest specimen measuring 1035 cm.; mandibular teeth 23–28, average 25.4; maxillary teeth 24–29, average 26.5; palatine teeth 7–10, average 8.7; pterygoid teeth 22–27, average 24.9.

The range of variation for specimens for which scale counts are recorded in the literature is as follows: midbody scale rows 35–43, average 39.2; ventrals 179–200, average 190.1; caudals 35–48, average 44.8; sum of ventrals and caudals 220–247, average 235.7.

A specimen labelled "probably New Britain" (Chicago Nat. Hist. Mus., No. 13886) appears to be a *carinatus-paulsoni* intergrade, resembling *paulsoni* in scale characters but *carinatus* in coloration.—Olive Griffith Stull, *Purdue University, Agricultural Experiment Station, Lafayette, Indiana.*

CERTAIN ASPECTS OF THE NATURAL HISTORY OF THE MUDTURTLE, *KINOSTERNON BAURI*.—Only sketchy data on the life history of *Kinosternon bauri* are available despite the fact that it is very common in aquatic situations within its range which extends from the barrier beaches to the Central Highlands of Florida. Most of the previous observations were made by Carr (1940, Univ. Florida Biol. Sci. Ser., 3: 1–118; 1952, Handbook of turtles: xv 542 pp.) and Pope (1939, Turtles of the United States and Canada: xvii + 343 pp.). Garman (1891, Bull. Essex Inst., 23 (7–9): 1–4) contributed to our knowledge of its occurrence and habitat on Key West; Van Hyning (1933, Copeia, (1): 3–7) reported on Alachua County specimens. The following account is based on 31 individuals: one adult female and two hatchlings of *K. b. palmarum* and 21 females, two males and five hatchlings of *K. b. bauri*. The adult *K. b. palmarum* was taken near Homestead, Dade County; the 23 adults of *K. b. bauri* were collected in Brevard County.

Habitat.—Most of the striped mudturtles (*K b. bauri*) were captured in or about a small coastal hammock pond where they appeared to be the sole chelonian species. The pond is located on the Indian River lagoon side of a barrier beach and drains into the river about 25 yards away. The pond is only a few inches deep and becomes dry occasionally. The plants of its environs include the royal fern (*Osmunda regalis*), cabbage palm (*Sabal palmetto*), and southern red-cedar (*Juniperus silicicola*) as described by (Kurz, 1942, Florida Geol. Surv., Geol. Bull., 23: 154 pp.). On February 21, 1954, duckweed completely covered the surface of the pond, but five or six turtles could be seen moving about, for their carapaces projected above the surface of the shallow water.

Out of 24 individuals captured in various habitats, nine were taken on land and 15 from water. Only two of the 13 specimens taken from the hammock pond were taken on land, one 20 yards away and the other, a male, under a fallen cabbage palm frond, 3 yards from the pond. Other specimens were taken in such situations as the small streams that drain the bluff (west shore) of the Indian River lagoon, the pine flatwoods drainage canals to the west and, finally, the prairies and marshes of the St. John's River. The single Paradise Key mudturtle (*K. b. palmarum*) was taken on the bank of a mangrove-bordered canal.

Reproductive Potential.—Seventeen female *K. bauri* were dissected and the ovaries and oviducts were examined. Eggs were found to be present in the oviducts of eight *K. b. bauri* dissected from February 27 (first dissection) through April 19, 1954, but ovarian ova 15 mm. or larger were found to be present from February 27 through May 4, 1954. Three females, dissected August 4 and 11 and September 14, 1954, had no ova larger than 10.8 mm.; most of the larger ova were 4 or 5 mm. in diameter, the same size class found in most ovaries where follicles were recently expended of large ova. Two of the largest striped mudturtles (9.54 and 9.28 cm. in length) contained three shelled eggs; four turtles (9.00–8.14 cm.) contained two eggs; and the smallest (8.12 cm.), but one egg. In addition there are some indications that a turtle 10.47 cm. long can either lay two clutches of four eggs or as many as three clutches. The fact that there are usually, especially early in the season, at least as many ova 9.8 mm. or larger in the ovaries as there are oviducal eggs indicates that a second annual clutch is evidently deposited. The genitalia showed indications that the first clutch was laid from the middle to the latter part of March and the second in the latter part of April. If a second complement is laid, these mud turtles can be said to lay from one to six or more eggs per season, probably averaging about 4.5.

A female with a carapace 7.11 cm. long and 4.81 cm. wide proved to be sexually immature. On the other hand, a male 7.58 cm. long and 5.10 cm. wide, taken March 17, 1953, had its testes filled with spermatozoa. Random collecting produced two males as compared to 21 females.

A *K. b. palmarum*, dissected on March 11, 1954, was 10.35 cm. in length and contained 3 oviducal eggs. The ovaries contained seven ova that ranged in diameter from 10.2 to 16.0 mm., an indication that a second or third clutch could be laid.

Eggs.—Twenty oviducal eggs were removed, examined, placed in glass jars, wrapped in wet toweling paper and incubated at room temperature. *K. b. bauri* eggs are elliptical, brittle and porcelain-like. Upon removal from the oviduct the white translucent shell had a pinkish hue. Some of these

eggs did not have the shell completely deposited, and looked porous. These eggs never hatched, but one embryo lived to become 3.5 mm. long. Its yolk was intact and centered in the egg. The eggs that developed produced color changes with age comparable to that briefly described for *Kinosternon subrubrum steindachneri* and *Sternotherus odoratus* by Carr (1952, *op. cit.*), for they developed dull blue-white irregular bands around their centers after about one month or less of incubation. This dull white color is undoubtedly due to the development of embryonic membranes close to the semi-transparent egg shell. During this same period of time the yolk appeared to leave its central position in the egg and flatten against one end of the shell. After two months or less of incubation the eggs became tricolored, the original dull white completely encompassing one end; the color of the dark embryo and orange-yellow yolk was visible through the other end. Still later the white color encroached farther until there existed a uniform dull white china-like shell.

Seventeen *K. b. bauri* eggs ranged in length from 2.50 to 3.18 cm., mean 2.80; 1.58 to 1.72 cm. in width, mean 1.66. These measurements did not vary during the course of incubation and therefore a weight increase due to absorbed water is not to be expected (Cunningham and Hurwitz, 1936, Amer. Nat., 70: 590–5). The common mudturtle (*Kinosternon subrubrum subrubrum*) egg does not increase in weight either during the course of incubation (Lynn and Von Brand, 1945, Biol. Bull.: 112–27). Evidently the shell not only resists an increased amount of water but also resists desiccation, for *K. b. bauri* eggs left completely dry for some time developed normally. Cagle (1937, Jour. Tennessee Acad. Sci., 12: 87–95) reported that the muskturtle (*Sternotherus odoratus*) often lays surface-exposed eggs, which indicated comparable resistance to desiccation. A small air space is usually visible beneath one end of the shell just prior to hatching.

After 2 or 3 months of incubation and at least one month before hatching, a heretofore unknown phenomenon occurred in all *K. b. bauri* eggs. A single longitudinal crack formed in all egg shells and extended to and around the ends of the egg as incubation proceeded. Later this crack exuded small quantities of albumen and expanded slightly. In some cases this albumen became black, probably due to a fungus which apparently did not retard development.

The eggs of *K. b. palmarum* went through changes that were not distinguishable from those of *K. b. bauri*. Three such oviducal eggs measured 3.13 × 1.68, 3.12 × 1.69 and 3.18 × 1.70 cm.

Hatching and Hatchlings.—Five *K. b. bauri* hatched after an incubation period of from 96 to 129 days. The egg shell ruptured a second time, but this time in an entirely different manner. Close to one end of the egg and opposite each of the hatchling's eyes, two jagged holes about 3 mm. in diameter formed, first in the shell, and then in the shell membrane. The turtle's forefeet seemed to be most instrumental in accomplishing this. Furthermore, cracks radiated from these holes in various directions; some intersected the prehatching split. The turtle usually emerged through this end of the egg shell, most often without completely halving the egg longitudinally. A similar pipping procedure was described for the turtle, *Sternotherous odoratus*, by Carr (1952, *op. cit.*) but no mention was made of a prehatching crack. Complete liberation from the egg shell required from 2 to 65 hours. Two eggs from one female hatched within 5 hours and 50 minutes of one another; two eggs from a second female hatched within 8 hours and 45 minutes. The hatchlings had yolk sacs 5–7 mm. in length when completely free of the egg shell. In at least one individual the yolk sac was completely retracted 8 hours after the hatchling became free of the shell. The hatchlings were exceedingly active but not pugnacious unless provoked.

The mudturtles were measured right after they were free of the egg shell as well as 1 and 3 months later (Table I).

The hatchlings possess a weak medial keel and a

Table I

The Growth of Hatchlings of *Kinosternon bauri*

All measurements are maximum in mm. The hatchlings were kept in an aquarium and fed on liver, fish, etc. Nos. 1 and 2 are from the same female and 4 and 5 from another. No. 3 is a dead hatchling *K. b. palmarum*

Specimen No.	Length of carapace			Length of plastron			Width of carapace			Height		
	Hatchling	One month	3 months	Hatchling	One month	3 months	Hatchling	One month	3 months	Hatchling	One month	3 months
1.	22.8	22.0	23.8	18.9	18.8	19.7	16.8	18.5	20.7	14.5	13.2	13.3
2.	22.8	23.4	26.2	19.8	20.5	21.8	14.0	19.8	22.8	15.5	12.2	14.0
3.	21.2	...	...	18.2	...	...	15.4	...	...	18.2	...	...
4.	25.0	25.8	30.2	20.3	20.4	23.8	17.2	21.1	22.8	15.2	14.1	15.8
5.	24.8	25.9	28.8	20.9	21.2	22.0	17.2	21.1	23.8	14.8	13.1	15.2
6.	20.5	...	25.5	18.1	...	21.8	16.1	...	23.3	12.8	...	14.2

similar lateral one. The dark areas are coal black and the light areas, that is the stripes on the head and carapace as well as regions of the marginals and plastron, are from light yellow to orange-yellow in color. In young turtles new growth areas bordering laminae are comparatively lighter in color and smoother in texture. Hatchlings lack the functional anterior and posterior plastral hinges but acquire them by the third month. They are similar to adults in possessing two or three parallel, transversely elongate scales on the anterior foreleg as well as a pair of barbules on the neck and a pair on the chin. The egg teeth were lost 27 to 31 days after hatching.

The single hatchling *K. b. palmarum* died before it could free itself from the egg shell. It is impossible to determine the race of this individual on the basis of the opacity or translucency of the dorsal laminae.

Food and Feeding.—Four of the *K. b. bauri* ate pieces of liver between 19 and 24 days after hatching; a turtle 9 days old refused this kind of food. Hungry young turtles bit at numerous inedible objects if they were new to their environment. Often the young fought (biting at one another's legs) over objects like carrots or wax paper, which they bit at but never ate. Such biting and fighting soon subsided, however, but could be provoked again by introducing liver blood, or fish juice. These small turtles would snap indiscriminately at the water of the aquarium when blood was added to it. At least one such trial-and-error biting seemed to locate food when sight did not.

Alimentary canal analyses of 15 striped mudturtles proved them to be omnivorous. The vegetable portion of their diet included the seeds of the cabbage palm (*S. palmetto*) in considerable abundance and frequency. A common green substance was tentatively identified as an algae. The most frequent of identifiable organisms was small snails, but insect fragments including an aquatic larva, and beetle elytra were identified. Miscellaneous objects included were small bone fragments, vertebrae, juniper leaves and other vegetable debris.—Gerald E. Einem, *Melbourne High School, Melbourne, Florida.*

THE AMPHIBIANS AND REPTILES OF WINNEBAGO COUNTY, ILLINOIS.—Winnebago County, one of the northern tier of Illinois counties, is approximately midway between Lake Michigan and the Mississippi River. Most of the area consists of rolling prairie country. The major streams are the Rock River, which flows southward through the county along the eastern side, the Pecatonica and Sugar Rivers, both of which enter the Rock River in the northern part of the county, and the Kishwaukee River, which enters the Rock River from the southeastern part of the county. A few limestone outcrops, some with abandoned quarries, occur along the rivers, but much of the area is extensively cultivated or grazed. A few stands of deciduous forest remain.

This area is adjacent to the Chicago area which is relatively well known herpetologically. Although papers by Schmidt, Necker, Pope, Edgren, Stille, A. G. Smith, and others provide a wealth of distributional information for the amphibians and reptiles of northeastern Illinois and corners of the adjacent states, the area immediately to the west is one of the least studied parts of Illinois. No list of the species of the region has been published; and, except for a few species of turtles recorded by Cahn (1937) and Fritsch (1940), localities in north-central Illinois are rarely cited in the herpetological literature. The usefulness to herpetologists of the various papers treating the Chicago area fauna has prompted me to publish an annotated list of the species known for Winnebago County. Although all the species recorded herein are also known in the Chicago region, some have been previously unknown farther west, and the known ranges of these species accordingly are extended a few miles in the present paper. Differences in comparative abundance of a few forms are suggested for these two contiguous regions, and a few species deserve comment because of their intergradient character.

The material on which this study is based has been collected during the past 5 years. Preserved specimens of every species recorded have been deposited in the collections of the Illinois Natural History Survey or the Rockford Museum of Natural History. The abbreviations, INHS and RMNH, refer, respectively, to these institutions. Localities cited, without these initials following, are based on specimens in my personal collection or in the collections of my associates of the Winnebago County Herpetological Society. I am indebted to W. S. Brooks, R. E. Fleming, J. T. Gladish, O. W. Olson, J. E. Hawkinson, and L. E. Kruse for sharing field work with me. I am indebted to Miss Dorothy Butts, Mr. E. G. Fritsch, Mr. Arthur Satre, Mr. Kenneth Harmet (East Rockford High School), and Dr. Paul W. Parmalee (Illinois State Museum) for helpful comments, and to Dr. Philip W. Smith (Illinois Natural History Survey) for guidance in the preparation of the manuscript. My father, Mr. Oliver Olson, and Mr. Milton Mahlburg, Curator of the Rockford Museum, have provided constant interest, encouragement, and advice.

Ambystoma laterale Hallowell.—This species has been found only near Yale Bridge on Sugar River approximately 7 mi. NW of Shirland (INHS), despite intensive search of other seemingly suitable localities within the county. This salamander is otherwise known in Illinois from Cook and Lake counties where it is apparently common. There is some possibility that the species no longer exists in

Winnebago County, since the Yale Bridge habitat has recently been completely destroyed by the rechanneling of the Sugar River.

Ambystoma tigrinum tigrinum Green.—Tiger salamanders have been taken at Loves Park, 3 mi. W of Perryville (INHS), Rockford (INHS), 5 mi. E of Rockford, and in Rock-Cut Forest Preserve. Most of the specimens have been found during excavating processes or discovered in window wells into which they had fallen during their fall migration. The species is not rare, but individuals are usually encountered by accident.

Necturus maculosus maculosus Rafinesque.—Specimens are available from Kilbuck Forest Preserve, Perryville (INHS), and Rockford (RMNH). Despite the few specimens extant, the waterdog is probably common in the rivers and larger creeks. It is often reported by fishermen. The local specimens do not seem to show affinities with *N. m. stictus* of central Wisconsin.

Notophthalmus viridescens louisianensis Wolterstorff.—This salamander has been seen only at the Yale Bridge area (INHS). Three specimens have been seen, two of which were efts.

Bufo terrestris americanus Holbrook.—Specimens of this abundant toad are available from ½ mi. E of Perryville (INHS), Rock-Cut Forest Preserve and Yale Bridge. Breeding in this region occurs during the first three weeks in May.

Acris crepitans blanchardi Harper.—Cricketfrogs are common throughout the county. Specimens are preserved from Pecatonica (INHS), 2 mi. N of Pecatonica (INHS), Pipersville (INHS), Rockford (INHS), 7 mi. NW of Rockford (INHS), Rockton (INHS), 5 mi. SW of Roscoe, and near Shirland (INHS). Though this frog is the earliest to emerge from hibernation, it does not begin calling until May, continuing until mid-July.

Pseudacris nigrita triseriata Wied.—Specimens of the chorusfrog are extant from 7 mi. NW of Shirland (INHS) and 3 mi. W of Perryville. Breeding occurs from early April through mid-May. Tibia length/body length ratios for a series of seven adults range from 42.0 to 43.2, averaging 42.2.

Hyla crucifer crucifer Wied.—Springpeepers are available from 5 mi. NW of Shirland (INHS). Singing occurs between April 1 and late May in the Shirland area. Despite its abundance in the breeding ponds, only five individuals have ever been collected later in the season.

Hyla versicolor versicolor Le Conte.—Common treefrogs are known from 2 mi. W of Perryville (INHS), 3 mi. W of Perryville (INHS), and Rock-Cut Forest Preserve. Breeding occurs from the last week of April through May, although during the extremely dry seasons of 1953 and 1954 no calls at all were heard. The posterior surface of the thighs of the local specimens usually bears a loose reticulum of brown and orange-yellow, and these markings appear much less prominent than the thigh patterns of comparative material from farther south.

Rana catesbeiana Shaw.—There is an introduced population in Rock-Cut Forest Preserve. Recent collections from there seem to indicate that the specimen count has dropped considerably.

Rana clamitans melanota Rafinesque.—Greenfrogs are the most conspicuous amphibians in the county. Specimens are known from Franklin Springs (INHS), ½ mi. E of Perryville (INHS), Rockford (INHS), 5 mi. N of Rockford (INHS), Roscoe (INHS), and 7 mi. NW of Shirland. The breeding peak apparently occurs in the fall in this area, as clasping pairs and eggs have been found in September. Singing, however, occurs from late spring until fall.

Rana palustris LeConte.—One specimen from 7 mi. NW of Shirland (RMNH) and another seen, but not obtained, from 10 mi. W of Rockford are the only known records of the pickerelfrog in the county. I have not found evidence of breeding or heard the call of this species.

Rana pipiens Schreber.—Meadowfrogs are abundant throughout the county. Specimens are available from Franklin Springs (INHS), 5 mi. S of Harrison (INHS), Pipersville (INHS), Rock-Cut Forest Preserve, Rockford (INHS), and 7 mi. NW of Shirland. These frogs occur in a variety of habitats, sometimes in fields well removed from water. Breeding occurs from late March into May. The local meadowfrogs have large, light-margined dark spots on the body, usually a heavy snout spot, and usually secondary raised ridges between the dorsolateral folds.

Heterodon platyrhinos Latreille.—Only four specimens, three of which are juveniles, have been taken, and these are all from 7 mi. NW of Shirland (INHS). Variation data for three males and one female are: ventrals 124, 122, 124, and 135; caudals 60, 46, 48, and 36; body blotches 25, 22, 29, and 31. Captives fed on newly transformed American toads.

Opheodrys vernalis vernalis Harlan × *blanchardi* Grobman.—A single specimen (INHS) of this species has been taken 5 mi. S of Rockford. This adult, a male, has 130 ventrals, 91 caudals, and single preoculars on each side. The rather low ventral count indicates influence of the nominate race; and, since the snake is from an area originally forested, the approach to *vernalis* is to be expected. Reports of greensnakes in parks within Rockford have not been substantiated by specimens.

Coluber constrictor flaviventris Say.—Blueracers have been taken at Kishwaukee Forest Preserve Rockford, (INHS), and 7 mi. NW of Shirland (INHS). Several other racers have been seen in the Shirland area. A small captive specimen, despite its

nervousness, fed on Dekay's snakes. A male and female have, respectively, 181 and 178 ventrals, 87 and (?) caudals, 7-7 supralabials, 8-8 infralabials, and 2-2 oculars, tail length percentages of 23.4 and (?).

Elaphe vulpina vulpina Baird & Girard.—Foxsnakes are common throughout most of the area studied. Preserved specimens are available from 3 mi. W of Perryville (INHS), Kilbuck Creek, Rock-Cut Forest Preserve, Rockford (INHS), 7 mi. N of Rockford (INHS), 6 mi. S of Rockford, Seward, and 7 mi. NW of Shirland (INHS). Variation data for two males and three females, respectively, are: ventrals 194 and 202, 203-210; caudals 64 and 65, 53-56; tail rings 11 and 11, 12-15. The number of dorsal body blotches in the five snakes ranges from 38 to 40.

Lampropeltis doliata triangulum Lacépède.—This species is known from Durand, Rockford (RMNH), 12 mi. W of Rockford, 7 mi. NW of Shirland (INHS) and Sugar River Forest Preserve (RMNH). The milksnake is rather uncommon, but 26 individuals in the Yale Bridge area were found within a short time by raising rocks. This may have been a prehibernating aggregation, as the snakes were found in the fall of the year. A newly captured specimen disgorged four mice. Variation data for one male and three females are as follows: ventrals 209 and 201-204, caudals 35 and 42-46, supralabials 7-7 in all, infralabials 9-9 in all. The number of body blotches ranges from 33 to 43; the number of tail rings, from 8 to 10. Occasional specimens are decidedly red, suggesting *syspila*, but the sizes of the individual blotches and the head patterns are typical of triangulum.

Natrix sipedon sipedon Linnaeus.—This watersnake is common. Preserved specimens are available from Kilbuck Creek, Perryville, Rockford, 7 mi. N of Rockford (INHS), and 7 mi. NW of Shirland. Variation data for a male and two females are: scale rows 23-23-17, 23-23-18, and 23-24-18; ventrals 145, 146, 146; caudals 78, 67, 63; dorsal body blothces 36, 40, 40; and tail rings 20, 21, and 24.

Storeria dekayi wrightorum Trapido.—These small snakes are known from Kilbuck Creek, (INHS), Perryville, Rock-Cut Forest Preserve (INHS), Rockford (INHS), and 7 mi. NW of Shirland. Variation data for four females are as follows: scale rows 17 in all, ventrals 131-136; caudals 45-50, supralabials 7-7 in all, infralabials 7-7 in two, 7-8 in one, and 7-6 in one. Only two of the local snakes had the ladderback pattern presumably diagnostic for *wrightorum*. This snake is referable to this race, however, on the basis of ventral and caudal count sums and presence of markings on the anterior temporals.

Thamnophis radix radix Baird & Girard.—This abundant gartersnake is known from Page Park, Rockford (INHS), 2 mi. S of Rockford, 3 mi. N of Rockford, and Rockton (INHS). I have seen road-killed specimens from many other localities not listed. Variation data for six specimens are as follows: 19 anterior scale rows in five, 20 in one; 19 mid-body scale rows in five, 21 in one; posterior scale rows 17 in four, 16 in one, and 15 in one; ventrals 154-159 in males, 154 in females; caudals 70-74 in males, 65-67 in females. Seven individuals of approximately 30 in which color was noted had a bright red groundcolor on the back and sides. Occasional other specimens exhibit traces of red in the normally brown groundcolor.

Thamnophis sirtalis sirtalis Linnaeus.—The common gartersnake is less concentrated in our area than the preceding species. Specimens have been collected at Kishwaukee Forest Preserve, Rock-Cut Forest Preserve (INHS), and 7 mi. NW of Shirland (INHS). Two males have 19-19-17 scale rows, 152 and 158 ventrals, 74 and 77 caudals, and 7-6 supralabials.

Chelydra serpentina serpentina Linnaeus.—A specimen from Rockford (RMNH) has been preserved. Almost every body of water in the area harbors this species, but no attempt has been made to obtain series. A captive male attempted copulation with a female *Pseudemys s. elegans* (from Louisiana) in January. The snapper clamped onto the shell of the slider by hooking its claws and tail under the marginal plates of the slider, but her smaller size made it impossible for the snapper to maintain its position.

Sternotherus odoratus Latreille.—Numerous specimens (INHS) have been taken near Perryville. Cahn (*op. cit.*) recorded the species from Rockford, although this reference likely means the general vicinity. I have been unable to find the muskturtle anywhere other than at Perryville. In December a male was observed repeatedly mounting a slightly larger female. The male followed the female, swimming with his neck outstretched, and he continuously nudged her beneath the carapace with his snout. When the female was overtaken, the male swam over her, forcing her to withdraw her head into the shell by rubbing his mental tubercles across her snout. The male clamped his feet firmly under her carapace and extruded his tail under the posterior margin of her carapace, but actual copulation was never observed. This female was also courted by another, less determined male.

Emys blandingi Holbrook.—Specimens have been collected at Perryville (INHS), Rockford, 3 mi. W of Rockton (INHS), and 7 mi NW of Shirland. Other individuals have been seen in other parts of the county, but the species is not abundant.

Graptemys geographica LeSueur.—The University of Illinois Museum of Natural History has a specimen of this species from Rockford. Although I be-

lieve I have seen mapturtles in the Rock River, 10 miles south of Rockford, I have not been able to obtain any.

Chrysemys picta marginata Agassiz × *belli* Gray.—Painted turtles are available from Kilbuck Creek, Perryville (INHS), and Rock-Cut Forest Preserve. The specimens at hand are almost exactly intermediate in plastral patterns between *belli* and *marginata*, and the influence of neither race can be said to predominate. In the nearby Chicago area, however, the influence of *marginata* is clearly predominant.

Trionyx ferox spiniferus LeSueur.—Specimens have been taken from Kinnikinnic Creek, Kishwaukee Forest Preserve (INHS), and ½ mi. S of Shirland, and specimens have been seen from still other localities in both streams and ponds. A slight influence of *T. f. hartwegi* may be suggested by the carapace patterns, but this is not certain with the few specimens available. The local specimens would key out as *spiniferus* on the basis of the unequal-sized carapace ocelli.

There are a number of other species known from adjacent regions which may be found in Winnebago County. Some of these seem almost certain to occur in our limits; others are rare throughout northern Illinois and their occurrence cannot be predicted. The more striking omissions in this list are *Ambystoma maculatum*, *Rana catesbeiana*, *Rana sylvatica Storeria occipitomaculata*, *Natrix septemvittata*, and *Natrix grahami*, all of which are relatively common in parts of the Chicago area. It is perhaps significant that these species have not been found, despite special search for them. There is some sand in Winnebago County which might be expected to support populations of *Bufo woodhousei*, *Ophisaurus*, *Cnemidophorus*, *Pituophis*, and *Terrapene ornata*, but no evidence of their occurrence is now available.—R. Earl Olson, *Bethel College, St. Paul, Minnesota.*

Ichthyological Notes

CAPTURE OF AN IMMATURE OAR-FISH, *REGALECUS GLESNE*, IN THE GULF OF MEXICO.—On February 26, 1955, a specimen of the oar-fish, *Regalecus glesne*, was found in the catch of a 100-foot shrimp trawl during exploratory fishing operations aboard the M/V OREGON, research vessel of the U. S. Fish and Wildlife Service. The drag was made in 225 fathoms some 90 miles south of Mobile, Alabama, at 29° 14′ N., 87° 53′ W. While the oar-fish is not infrequently taken in Australian and New Zealand waters, its capture in the western Atlantic is rare; apparently the only records are for a 17-foot specimen washed ashore at Hungry Bay, Bermuda, in 1860 (Goode and Bean, 1895, Smith. Contr. to Knowl., 30: 480–1), and for a 7-foot specimen stranded on the beach at Long Key, Manatee County, Florida, on March 20, 1920 (Welsh, 1920, COPEIA, 86: 79–81).

The body surface was covered with a silvery "guanin," which rubbed off at the slightest touch. Only traces of this substance now remain on the fish (U. S. National Museum no. 164226).

The first five dorsal rays are greatly produced and unequal in diameter, with the first, fourth, and fifth approximately twice as heavy as the second and third. No bulbous tips were observed on any of these rays. Minute black pigment spots are scattered on most of each ray, becoming more concentrated on the terminal four millimeters. The remaining dorsal rays, approximately 390 in number, become more closely spaced posteriorly. Minute black pigment spots mark the interspaces between each ray.

The pelvics are single rayed, with a low translucent "keel" along their posterior edges. This structure is minutely produced and pigmented for about one-third of the length from its insertion. At two-thirds of its length from insertion this "keel" forms an additional filament-like structure with a heavily pigmented flap in the fork. In the terminal portion the "keel" is produced once more into a heavily pigmented flap giving the end of the ray a bulbous appearance.

Numerous small clusters of black pigment spots, pin-point in size, are irregularly spaced over the body, and are more heavily concentrated on the ventral surface. A cluster of these appears directly over each eye, and they vary in size from minute to about 0.3 millimeters in diameter.

Pertinent measurements in millimeters are as follows: standard length, 179.5; total length, 222.5; head, 14.7; greatest body depth (at first dorsal insertion), 9.7; body depth at pelvic insertion, 9.2; body depth at anus, 6.0; snout, 3.0; gape, 4.1; horizontal diameter of eye, 3.4; pupil diameter, 1.0; snout to mid-pupil, 5.0; snout to anus, 70.2; snout to insertion pelvics, 16.0; mandible length, 5.1; caudal (4 rays), the longest ray, 43.0; longest dorsal ray, 53.0; length of pelvics, 58.0.—Harvey R. Bullis, Jr. and Edgar L. Arnold, Jr., *U. S. Fish and Wildlife Service, Pascagoula, Mississippi, and Galveston, Texas.*

SPAWNING MORTALITY OF THE THREADFIN SHAD, *DOROSOMA PETENENSE* (GÜNTHER), IN FLORIDA.—On the afternoon of April 11, 1955, the effects of an evident spawning mortality of the threadfin shad, *Dorosoma petenense* (Günther), were observed on the west shore of Lake Newnan, near Gainesville, Florida. Masses of densely packed fish eggs, about 0.75 mm. in diameter, were adherent to submerged moss fibers, cypress roots, and small plants. The eggs were apparently confined to a forty yard area along the shore. Fifteen dead threadfin shad were recovered from this area. Nine of these were entrapped in moss fibers; the others had been washed to the shore. The slight evidence of decomposition indicated that death had occurred no earlier than that morning. The head of one shad and the tail of another had been chewed off; the others showed no evidence of injury or predation. Four of the shad were gravid females, all about 127 mm. in total length, that had partially spawned. They still contained eggs that were readily extrusile. Eggs in the posterior portions of the ovaries were of the same general size and appearance as those in the water. The eleven males, ranging from 99 to 132 mm. T. L., had enlarged testes and had recently extruded milt.

These deaths are considered a parallel to the massed mortality of the gizzard shad, *Dorosoma cepedianum* LeSueur, that occurs during the latter portion of its spawning season, about April and May, in Lake Newnan (Berry, 1955, Unpublished Masters Thesis, University of Florida).

An additional observation supplemented the above conclusion. During the morning of April 15, 1955, thousands of threadfin shad were observed dead and dying in the cove of a fishing camp on Lake Harris, near Leesburg, Florida, about 60 miles SSE of Lake Newnan. In the afternoon no live shad could be seen, but immense numbers of the dead were observed on the shallow bottom and floating on the surface. Water hyacinth roots and pilings were thickly coated with the adherent shad eggs, of the same average size as those from Lake Newnan. A random sample of the dead shad showed all to possess mature gonads, similar in condition to those examined from Lake Newnan. The 32 females examined ranged from 58 to 70 mm. T. L.; the 52 males, 44 to 67 mm. T. L.

No physical or chemical data are available from either lake at the time of the observed mortalities. However, appraisal of the U. S. Climatological Data records for both areas discredits temperature as a causal factor in this mortality other than its probable influence on the time of spawning. In the Gainesville district, a three day low of the mean daily air temperature had risen from 38°F. on March 29 to 64°F. by April 1 and remained between 64° and 76°F. through April 15, with no abrupt changes or extremes.

Shortly after a prolonged cold wave in central Texas, Hubbs (1951, Copeia, No. 4, p. 297) collected many recently dead threadfin shad (*Signalosa petenensis atchafalayae* Evermann and Kendall) in the Colorado River and assumed a minimum temperature tolerance for the species to be between 54° and 57.6°F. (converted from °C.). Parsons and Kimsey (1954, Prog. Fish-Cul., 16(4): 108) found high mortality (citing the same subspecies) to occur when water temperatures were experimentally decreased from 50° and 60°F. to below 45°F. and observed that very few fish survived water temperatures below 40°F. They state that there is often heavy mortality when the temperature drops suddenly. Only the one described evidence of mass mortality of the threadfin shad was observed in Lake Newman during almost daily visits to various parts of the lake. This mortality, although probably only a very small fraction of that which occurred, came at a time of relatively stable environmental conditions; the same was probably true for Lake Harris where temperatures averaged a few degrees higher than in the Lake Newnan area. Rather than the often cited causes of temperature change or oxygen depletion, the act of spawning, or partial spawning, seems to have been the triggering of these decimations.

The evident association of mass mortality and spawning noted in these two instances may account for the short average life span of less than two years of the species as reported by Parsons and Kimsey (*ibid.*, p. 179).

The size range of the dead threadfin shad found at Lake Newnan (99 to 132 mm. T. L.) closely approximated the average size of the species taken by bag seine in March, 1955. The threadfin shad from Lake Harris were notably smaller (44 to 70 mm. T. L.). Mr. John Parsons points out (personal communication) that this does not necessarily infer a stunted population of the Lake Harris shad. He writes that there has been much evidence in Tennessee, California, and Virginia that young threadfin shad mature by the first fall and may spawn in the fall as young-of-the-year fish; and that the Lake Harris shad may have had a poor spring hatch and a good fall hatch, thus lowering the average size yearling the following year. In addition, he states that young-of-the-year, yearling, and two year old threadfin shad usually remain in individual schools. FREDERICK H. BERRY, *Department of Biology, University of Florida, Gainesville, Florida,* and MELVIN T. HUISH *and* HAROLD MOODY, *Florida Game and Fresh Water Fish Commission, Leesburg, Florida.*

A MORTALITY OF THE SAND LAUNCE, *AMMODYTES AMERICANUS.*—A mortality of the sand launce, *Ammodytes americanus*, occurred during the spring of 1954 in the lower end of

Narragansett Bay in the vicinity of the Narrangansett Marine Laboratory of the University of Rhode Island. Dead sand launce were observed accumulating on the beach in front of the laboratory during May 19. On May 20, a sample of dead launce in good condition was collected from the beach, and gross examination showed slight hemorrhage of the eyes and brain. Seining on May 21 with a 150 foot seine to a depth of six feet demonstrated that the dead launce were floating in from offshore and not dying in the shallow water adjacent to the beach. The mortality probably began during May 18 and ended during May 21.

Although the cause of the mortality was not determined, an analysis was made of its effect on the population of sand launce in the area. A collection of live sand launce was taken in a 150 foot seine on June 3 in the mortality area. A comparison between the samples of "dead" and "live" launce showed that they were identical in regard to their size distribution at the 5% level (see Table I).

It has been shown previously (Keys, 1931, Bull. Scripps Inst. Oceanog., Tech. Ser., 2(12): 417–490; Graham, 1954, Ph.D. Thesis) that mortalities can select out a certain part of the morphological range of a population of fishes. The head, containing the gills and oral members, is the center of physiological exchange between the internal media of a fish and its environment. Therefore, a comparison of head length relative to body length was undertaken between the "dead" and "live" samples. Head length was considered to be the distance between the anterior tip of the upper jaw and the most distal point of the operculum, thus excluding the specialized lower jaw. Head length was measured with a vernier caliper reading to 0.1 mm. and standard length with a steel rule reading to 1 mm. with estimates made to the nearest 0.1 mm. The data were then stratified at 0.05 logarithmic intervals with ten specimens, when possible, to each class.

Figure 1 shows a comparison of slopes for head length to body length between the two samples. The slopes (K = 0.82) were not significantly different at the 5% level. However, intercepts were found to be significantly different at the 1% level as shown in Table II.

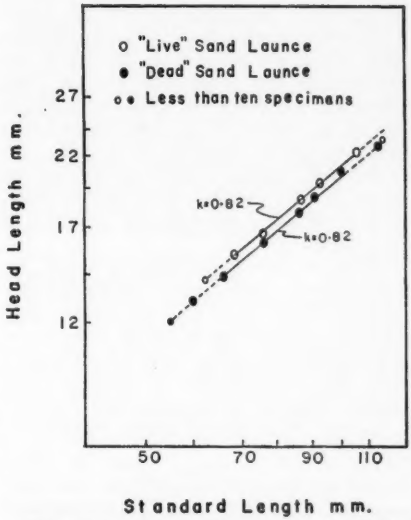

FIG. 1. Comparison of head length relative to standard length between mortality and non-mortality samples of the sand launce, *Ammodytes americanus*. Those points used in statistical analysis are joined by a solid line and contain 10 specimens.

There are three possible explanations for this difference: (1) the trunk of the "dead" fish may have lengthened following death, but the head remained a constant size; (2) the "dead" and "live" samples may represent different year classes or groups of fish and (3) natural selection had taken place. The first appears doubtful because the extent of lengthening would be considerable. A fish with a trunk about 73 mm. long would have to lengthen approximately 4½ mm. or 6% of its original trunk length. In addition, both samples were dead when preserved

TABLE I

STATISTICAL ANALYSIS OF SIZE RANGES OF SAMPLES OF "DEAD" AND "LIVE" SAND LAUNCE

	Mean	Standard Deviation	Standard Error	Normal Deviate	P
	mm.	*mm.*	*mm.*		
"Dead" Sand Launce, 190 specimens.....	82.94	13.50	0.98	0.78	0.45
"Live" Sand Launce, 289 specimens.....	82.30	14.14	0.83		

TABLE II

ANALYSIS OF HEAD LENGTH—BODY LENGTH RELATIONSHIPS BETWEEN SAMPLES OF "DEAD" AND "LIVE" SAND LAUNCE

	(x) G.M. (y)	S X 2	S X y	S_{y^2}
"Dead" Launce....	9.6207 6.2177	18.5343	11.9827	7.7477
"Live" Launce....	9.6513 6.3327	18.6517	12.2422	8.0359

Test for Significance

(Slopes)

F ratio = 0, P > 0.05 = 5.99: Not significant

(Intercepts)

F ratio = 201.77, P < 0.01 = 12.25: Significant

and the "dead" sample was very fresh. The second explanation offered is probably voided by the agreement between size ranges of the two samples and the restricted area of sampling. The last would appear the most reasonable. Thus, the position of the line in Figure 1 for the "dead" sand launce sample (parallel to but some distance below that of the "live" sample) suggests that the smaller-headed fish were selected out by the mortality, probably leaving a more resistant population of sand launce.

This is the third species shown to undergo the above type of natural selection. Perhaps the selection of the larger headed fish with relatively larger gill and oral surfaces under certain circumstances is a common phenomenon. Such differential mortality might be responsible for "racial" or "subspecific" differences among many fishes.—JOSEPH J. GRAHAM, *Pacific Oceanic Fishery Investigations, Honolulu, Hawaii.*

THE SYSTEMATIC POSITION OF THE INDIAN CYPRINID FISH, *CIRRHINUS FASCIATUS* JERDON (1849), WITH A NEW NAME FOR *BARBUS FASCIATUS* BLEEKER (1853).—Jerdon (1948, Madras Jour. Litt. and Sci., 15: 305) placed a heterogeneous assemblage of eleven species under the genus *Cirrhinus* Oken. One of these, *Cirrhinus fasciatus*, he described from the headwaters of the Cauvery River and from Malabar. Günther (1868) listed *C. fasciatus* Jerdon as one of the insufficiently characterized species of *Tylognathus* Heckel. Although brief, the description of *C. fasciatus* is sufficiently clear to help in assigning the species to its proper systematic position. The writer's extensive collections from Jerdon's type localities have facilitated this task. Undoubtedly, *C. fasciatus* and two other nominal species, namely *Labeo melanampyx* Day (1865) from the Travancore Hills and *Barbus grayi* Day (1867) from the Bowany and Kallar rivers (tributaries of the Cauvery River) at the base of the Neilgherries, represent one and the same species. Day (1876) seems to have been aware of this, for he recognized *Barbus melanampyx*, with *C. fasciatus* and *B. grayi* as its synonyms. Evidently the earlier-proposed name *fasciatus* was not used to designate the species, as he considered it preoccupied by *Barbus fasciatus* Bleeker (1853, Nat. Tijdschr. Ned. Indies, 5: 190) from the East Indies.

C. fasciatus Jerdon and *B. fasciatus* Bleeker are at present both referable to the genus *Puntius* Hamilton, but are specifically distinct. It is highly doubtful whether any eventual splitting of the genus *Puntius* on characters like the barbels would separate these species. Hence, under the International Rules of Zoological Nomenclature, *fasciatus* Jerdon, which has priority over *fasciatus* Bleeker, will have to be considered as valid. This leaves Bleeker's species without a name, for which the specific name *Puntius eugrammus* sp. nov., is proposed here. For a detailed description of *Puntius eugrammus* sp. nov., reference may be made to the description of *Puntius fasciatus* (Bleeker) as given by Weber and de Beaufort (1916, Fish. Indo-Austral. Archipel., 3: 184-185).

Puntius fasciatus (Jerdon)

Cirrhinus fasciatus Jerdon 1849, Madras Jour. Litt. and Sci., 15: 305 (type locality, Malabar).

Labeo melanampyx Day 1865, Proc. Zool. Soc. London: 298 (type locality, Mundakayam, Travancore).

Puntius melanampyx Day 1865, Fish. Malabar: 210, pl. 16, fig. 1.

Barbus grayi Day 1867, Proc. Zool. Soc. London: 293 (type locality, Bowany and Kallar rivers at the base of the Neilgherries).

Barbus arulius (*nec* Jerdon) Günther 1868, Cat. Fish. Brit. Mus., 7: 133.

Barbus melanampyx Day 1876, Fish. India: 570, pl. 139, fig. 1. Beaven, 1877, Handbook Freshwater Fish. India: 49. Day, 1889, Fauna Brit. India, Fish, 1: 316. Jenkins, 1909, Rec. Ind. Mus., 3: 298. Pillay, 1929, Jour. Bombay Nat. Hist. Soc., 33: 357. John, 1936, ibid, 38: 711. Misra, 1938, Rec. Ind. Mus., 40: 258.

Barbus (*Puntius*) *melanampyx* Hora and Law 1941, Rec. Ind. Mus., 43: 793. Silas, 1949, Jour. Bombay Nat. Hist. Soc., 48: 793; 1951, ibid, 49: 673; 50: 326.

The natural distribution of *Puntius fasciatus* (Jerdon) in Peninsular India is the upper reaches of the Cauvery drainage and further southward to the Cape; also the western watersheds draining South Kanara, Malabar, and Travancore-Cochin.—E. G. SILAS, *Scripps Institution of Oceanography, University of California, La Jolla, California.*

THE JOLTHEAD PORGY, *CALAMUS BAJONADO* (BLOCH AND SCHNEIDER), A FIRST RECORD FOR NEW ENGLAND WATERS.—A porgy taken by Captain George Berg on the dragger "Old Mystic" off Watch Hill, Rhode Island, on November 25, 1955, aroused considerable interest because of its size. Weighing 9 pounds 8 ounces, this specimen was the largest porgy ever seen in the area. It was sent to the Bingham Oceanographic Laboratory and was found to be a jolthead porgy, *Calamus bajonado* (Bloch and Schneider). The specimen, which is now in the Bingham Oceanographic Collection of Yale University, appears to be the first *C. bajonado* recorded from north of Bermuda, and extends the range of the species by about 750 miles.

The following characteristics were observed: Total length 650 mm; standard length 520 mm; D. XII, 12; A. III, 11; scales above lateral line 8, along lateral line 55, below lateral line 18; gill rakers short and stubby, 5 on upper limb, 1 at angle, 6 on lower limb. Head 3.3; depth 2.4; pectoral 3.1, long, reaching past anal origin, all in standard length. Snout 1.7; eye 6; longest dorsal spine 2.5, all in head. Teeth 12/13, the outer anterior ones more or less canine-like, two of these on each side in upper and three in lower jaw, posterior teeth molariform. Molars in three series in upper jaw, two in lower jaw, small molar teeth between the main rows in anterior portion of each jaw. First interhaemal spine pen-like, receiving posterior end of air bladder. No antrorse spine before dorsal fin. Color of specimen four days after capture, uniform dull grassy violet, fins plain, dorsal slightly darker than other fins.

The jolthead porgy is a southern species, its normal range including Brazil, the West Indies, Florida and Bermuda. Although it is not uncommon to find other southern species off the coasts of Connecticut and Rhode Island, such strays usually appear in August through the middle of October, and are most often fishes of a more pelagic nature. To find a southern, bottom-dwelling species like the jolthead in New England waters in late November is therefore surprising and leads to speculation as to how it arrived. The rather close superficial resemblance between the jolthead and the common scup, *Stenotomus chrysops* (Linnaeus), particularly after the colors have faded, suggests that the jolthead may reach this northern area more often than the single present record would indicate. It is possible that in the hasty sorting of the catch on a commercial vessel, a jolthead would not be distinguished from a scup unless, as with the present specimen, it was so large as to stand out prominently and thus catch the attention of the fishermen.—James E. Morrow, *Bingham Oceanographic Laboratory, Yale University, New Haven, Connecticut.*

TERRITORIALITY IN YOUNG TIGERFISH, *THERAPON JARBUA*.—On December 4, 1953, Steinhart Aquarium received a Hong Kong shipment of 115 *Therapon jarbua* averaging about one inch in total length and presumed to be not more than two months old. They were placed by themselves in a 150 gallon rectangular exhibition tank with glass sides and sand bottom (5 feet x 2½ feet). The depth of the salt water was two feet, the temperature fairly constant at 75°F., and the rate of flow through the tank two gallons per minute. Territorial behavior had not been observed in the few individuals we had previously raised and thus we were rather surprised to find that after about two months the fish began to establish territories. At this time they averaged some two inches in total length. Nearly every fish had constructed, or was constructing, a small crater in the sand. This was guarded with a flexible possessiveness that could be transferred to other craters if the original was lost while the owner was temporarily away foraging. A fish approaching an occupied crater would usually find the owner darting out towards him, although there seemed to be no real aggressiveness in this action on the part of the attacking fish. The craters were constructed by a fish swimming about in a small circle. At irregular intervals the fish would swim to the bottom, and using the abdomen as a scraper, push the sand outwardly. In order to see how fast the craters would be rebuilt, the sand bottom of the tank was smoothed over. Within two days the craters had again been hollowed out. Although there were 68 fish in the tank at this time, there were only 58 craters, so that some of the fish were without definite crater territory.

In order to test whether this territoriality pattern might be because of crowding, all of the fish were removed from the tank, and then returned in groups of six. With only six in the tank there was some indication that the crater digging was diminished, but the fish still remained together in a small body, schooling in a loose group with a four to six inch interval between them. With the gradual addition of more fish to the tank some of the *Therapon* again built craters, but with increasing age, they seemed to lose that proclivity. After the tigerfish had been at the Aquarium for 7½ months (August, 1954), they were moved from their small tank to a 1000 gallon tank. At this time they were about 3 to 3½ inches in length. In the large tank the territoriality pattern seemed entirely lost. Thus there seemed to be two factors involved in this territoriality; (a) the effect of a confined space and (b) the age of the fish. Dr. A. W. Herre has suggested (in litt.) that the digging of a small crater by the young *Therapon* might be an adaptation for maintaining position in the tidal flow of the river mouths in which they live.

Our group of young *Therapon* was especially prone to shock, but seemed to outgrow this. On one occasion as the result of transferring 68 fish (2¼ to 2½ inches in length) from one tank to another, 12 went into shock and two subsequently died. At other times some have gone into shock merely as the result of having live brine shrimp placed in the tank with them.—Earl S. Herald, *Steinhart Aquarium, California Academy of Sciences, San Francisco 18, California.*

POSSIBLE PRODUCTION OF SUBSTANCES POISONOUS TO FISHES BY THE BOX FISH, *OSTRACION LENTIGINOSUS* SCHNEIDER.—In the course of experimental work with small, brightly colored reef fishes, the rapid death of such

fish have been observed when held captive in the same container with box fish in the field. The following observations concerned with the death of several species of reef fishes apparently due to confinement with a box fish have been extracted from the field notes concerned with this experimental work.

August 7, 1954. Punaluu, Oahu. A female box fish, about 8 cm. total length, was captured in a dipnet and added to a collection of other reef fish species contained in a one gallon wide-mouth jar. The other species in the jar were: one fantailed file fish *Pervagor spilosoma* about 5 cm. total length and about a dozen small (½ to 3 cm.) *Dascyllus albisella*. By the time I reached the beach, perhaps after an interval of ten minutes or somewhat more, all the fish except the box fish were dead. The jar was tightly capped.

August 8, 1954. Punaluu, Oahu. A male box fish, about 10 cm. total length, was captured in the same fashion as the one taken August 7, and placed in the one gallon wide-mouth collecting jar which contained at the time only a small fantailed file fish about 4 cm. total length. Within a few minutes of adding the box fish, the fantailed file fish was dead. Tentatively the death of fish on August 7 had been ascribed to overcrowding and oxygen lack. In an effort to prevent this, the lid of the jar had been filled with perforations, and the jar itself carried partially submerged on its side in order to secure some water circulation. Nevertheless, this precaution apparently served no purpose, which was puzzling in view of the fact that only two rather small fish were present in the jar.

August 18, 1955. Punaluu, Oahu. An 8 cm. female box fish was briefly added to a collection of other species held in a five gallon plastic bucket, after which the memory of the results of placing newly captured box fishes with others during the previous year caused me to remove it. The box fish was not in the bucket more than half a minute, yet many of the fish present in the bucket died by the time I reached the beach in spite of frequent changes of water. The bucket contained two *Chaetodon miliaris* 4 or 5 cm. in length, more than a dozen *Dascyllus albisella*, two *Labroides* sp., 4 to 8 cm. and a few other species not individually listed in the field notes. One *C. miliaris* and one *Labroides* sp. survived as well as a few *D. albisella*.

August 29, 1955. Punaluu, Oahu. A female box fish about 7 cm. in length was captured and placed by itself in a tightly capped quart jar of seawater. The fish was left in the jar until it had died, presumably from suffocation, in about 30 minutes. It was hoped that this treatment would cause the box fish to secrete a maximum of any substance toxic to fishes. Water from the jar was diluted by one gallon of clean seawater and then aerated vigorously for two hours by blowing air through an aquarium air stone. This aeration together with the addition of a gallon of fresh seawater should, under normal circumstances, render the water suitable for fishes. The aeration caused considerable foaming and the water although clear had a soapy appearance. Two small *Dascyllus albisella*—1 to 1½ cm. in length—were placed in a pint of the aerated mix in which aeration was continued for the duration of the experiment. One dascyllid died within 7 minutes and the other within 9 minutes after entering the mix. The dascyllids did not exhibit any of the usual symptoms of suffocating fish such as gasping or swimming with the mouth at the surface of the water.

Many species of reef fishes were successfully brought in by the methods described above. The deaths only occurred when the fish were confined with box fish. However, box fish may be kept in noncirculating aquaria with other fishes without difficulty. The deaths of other fishes after adding a box fish concerned here newly captured box fish excited and struggling for freedom. Tentatively I suggest that the box fish may be able to secrete some substance poisonous to other fishes, a substance released under stress and excitement. Presumably the ability to secrete such a hypothesized substance would serve to discourage predators.—VERNON E. BROCK, *Division of Fish and Game, Honolulu, Hawaii.*

NOTES ON THE OLFACTORY ORGANS IN CENTRARCHIDAE.—In most teleosts the entance to the nasal sac is double, by an anterior and a posterior naris, the former usually bearing a raised rim. The olfactory epithelium on the floor of the sac is usually elevated in a series of folds supplied by the olfactory nerve. There are frequently accessory pouches from the nasal sac, with a mechanical rather than olfactory function. The nasal organs have been studied by a number of authors, notably Burne (1909, Proc. Zool. Soc. London, 610–63), Derscheid (1924, Ann. Soc. Roy. Belgique, 54: 79–162), Van den Berghe (1929, Bull. Classe Sci., Acad. Roy. Belgique, 5 sér., 15: 278–305), Liermann (1933, Zeitschr. Anat. Entwickl., 100: 1–39), and Atz (1952, Anat. Rec., 113: 105–15 and Quart. Rev. Biol., 27: 366–77).

The present notes are made as part of an inquiry into relationships among the Centrarchidae. I should like to acknowledge the kindness of several individuals who have generously made material available: Mr. Wilbur I. Follett (California Academy of Sciences), Dr. Robert R. Miller (University of Michigan), Dr. Frank B. Cross (Kansas University), and Mr. John B. Funderburg (North Carolina State College).

In centrarchid fishes the epithelial folds radiate,

FIG. 1. Righ
cessory pouch;
FIG. 2. Righ
FIG. 3. Righ
FIG. 4. Dor

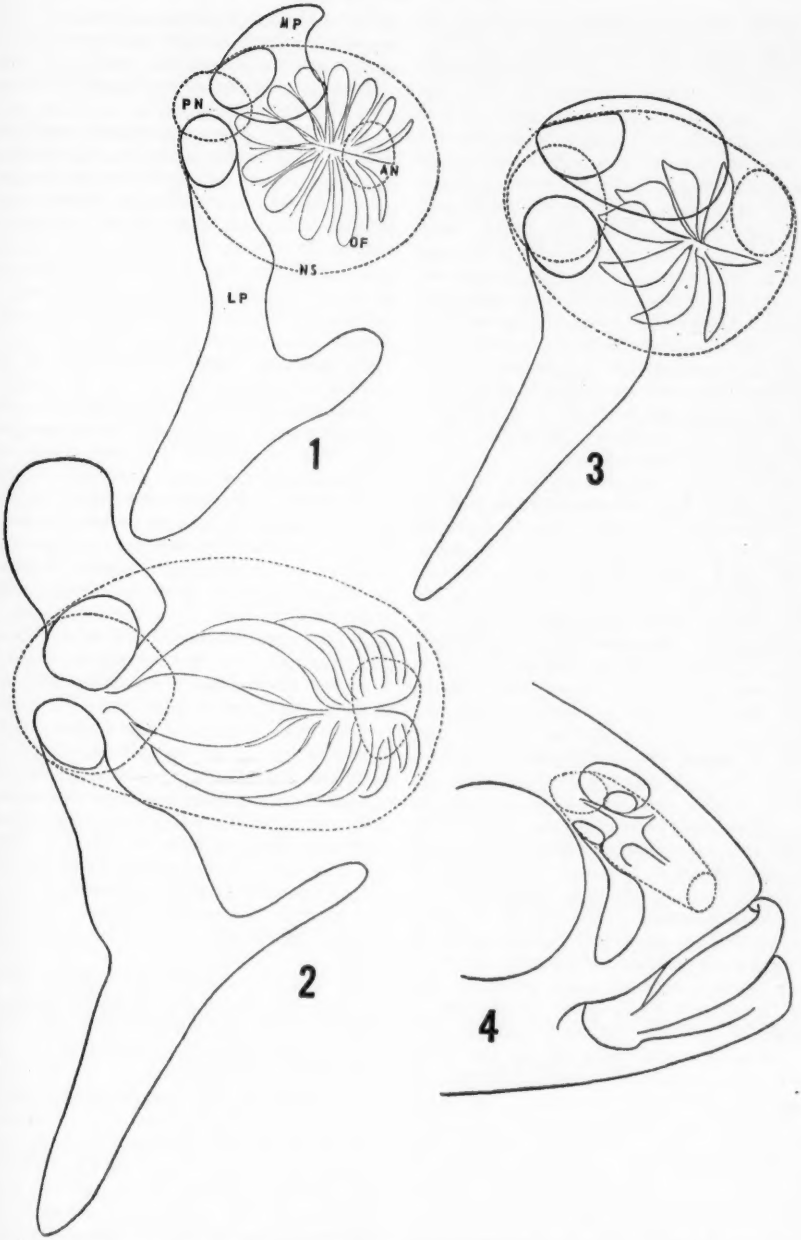

FIG. 1. Right olfactory organ of *Archoplites interruptus*. AN, anterior naris; LP, lateral accessory pouch; MP, median accessory pouch; NS, outline of primary nasal sac; OF, olfactory epithelial folds; PN, posterior naris.
FIG. 2. Right olfactory organ of *Chaenobryttus gulosus*.
FIG. 3. Right olfactory organ of *Micropterus s. salmoides*.
FIG. 4. Dorso-lateral aspect of head of *Elassoma zonatum*, showing right olfactory organ in relation to eye and jaws.

spoke-like, from a region approximately under the anterior naris. At the posterior end of the nasal sac are the round apertures of two accessory pouches, one extending mediad, the other ventro-laterad. The olfactory nerve passes back within the wall that separates the two apertures. The medial pouch (Ethmoidalsack of Liermann, 1933) extends toward the middle line, just behind the ascending process of the premaxillary, anterior to the mesethmoid, and beneath the nasal. The lateral pouch (Lacrimalsack of Liermann, 1933) is larger, and extends antero-laterad beneath the lacrimal but over the palatine, and posterior to the shaft of the maxillary. Often a diverticulum runs forward along the maxillary, up under the tip of the palatine. The mechanical pumping action of these two pouches is suggested by manipulation of the jaws, under water, during dissection, and by the following observation on a living *Lepomis gibbosus*. (Burne, 1909, found similar effects in *Perca fluviatilis*.)

A small blob of India Ink was placed in water near the nares. With each breathing movement, as the mouth opened, the maxillary was drawn slightly down, and this expanded the lateral secondary pouch, which drew in ink through the posterior naris. The median pouch also received some, but not as much as the lateral, for its movements (caused by protraction of the premaxillary) were relatively slight. Almost no ink entered through the anterior naris during the ordinary resting respirations. (At 75°F. these had a frequency of 140 cycles per minute, the opercular and pectoral fin movements both being coordinated with opening and closing of the mouth; this fish was 42 mm. in standard length.) During forcible protraction of the premaxillaries the median pouch enlarged greatly, but in normal movements both pouches showed only a small fractional change of volume, so that the ink remained in them through many cycles.

It seems reasonable to infer that the secondary pouches do not aid appreciably in drawing a current of water across the epithelial folds from the anterior naris, but that water and suspended particles are kept in turbulent motion in the posterior part of the primary nasal sac. This may prevent accumulation of debris in what would otherwise be an inert pocket, and incidentally maintain a gentle flow of water on the olfactory folds.

The nasal organs of adult *Archoplites interruptus*, *Chaenobryttus gulosus*, *Micropterus salmoides*, and *Elassoma zonatum* were examined in some detail, dissected under a binocular microscope, and are illustrated in the accompanying figures. Younger individuals of the first three were compared but not illustrated, as were specimens of a number of other species, as mentioned below. Each figure is drawn as a transparency, the broken lines outlining the limits of the right primary nasal sac and its two narial openings. The heavy solid lines show the medial and lateral secondary pouches and their openings into the primary sac. The light solid lines show the olfactory folds.

Figure 1 shows the nasal organ of a large (300 mm. S. L.) *Archoplites interruptus*. The olfactory epithelium in the floor of the sac has 12 *major* folds radiating, as shown, from a low central and anterior ridge. Each major fold is swollen, as if inflated. Between any two of these, except the first and second above, is a low, narrow, *minor* fold, not swollen. The medial secondary pouch is shown as indented on its anterior side because its soft wall is against the retracted premaxillary spine. The lateral pouch has a diverticulum forward under the head of the palatine.

That the development of the folds is correlated with size appears from the following (measurements are of standard lengths). A specimen of 110 mm. was similar to the large one, except that only the more posterior major folds were swollen. Anteriorly, the major and minor folds were equal. In a fish of 56 mm. and one of 48 mm. there were no folds, but some five or six radiating branches of the olfactory nerve could be seen in the position of folds, under the epithelium.

In *Centrarchus macropterus* (100 mm.) there are 11 pairs of folds, each pair evidently equivalent to a major and minor fold of *Archoplites*. The more posterior seven pairs consist of one swollen (major) and one small (minor) fold. The swollen ones are pigmented like the external skin. In this fish the folds are comparatively long, and radiate from a point immediately beneath the anterior naris.

In *Pomoxis annularis* (137 mm.) there are nine folds only. The most anterior (above and below) are not swollen, but all the others are. Hence these evidently represent only the major, not the minor.

A specimen of *Acantharchus pomotis* (114 mm.) has ten folds, the more posterior five of which are swollen.

Ten specimens of *Chaenobryttus gulosus* of different sizes were studied, and the largest (148 mm.) drawn (Fig. 2). This had 12 folds, as shown, all somewhat swollen, but no minor folds between. The secondary pouches are drawn as with the upper jaw retracted, but both expand greatly when it protracts. In a young individual of 24 mm. there is one distinct epithelial fold, equivalent to the most posterior and largest of those in the adult; the next fold above and below is barely evident. At 31 mm. there are three distinct folds, the more posterior being largest. At 54 mm. there are five folds; the more anterior upper one is not swollen but the others are. At 63 mm. another had been added beneath, in front (6). In fish of 73, 85 and 100 mm.

there are nine folds, at 110 mm. eleven folds, and in a specimen of 135 mm. ten folds. Thus it appears that in a general way the number and size of the folds is correlated with the growth of the fish, that the surface area of the epithelium increases in an allometric manner, that the first folds to appear during development are the posterior ones, and that others are added in front, both above and below the central ridge. On first appearance the folds are small and relatively narrow, but soon take on the inflated form.

A *Micropterus s. salmoides* of 198 mm. had seven simple folds as shown (Fig. 3); the appearance is of a propeller-shaped organ. The posterior folds have higher and more curved free edges, but do not appear inflated as those previously described. Protracting the premaxillary by 5 mm. results in approximately doubling the volume of the median accessory pouch. This is done by creating a reduced pressure in the space of the premaxillary socket over the vomer and anterior to the mesethmoid, so that the median wall of the pouch is sucked into that space, meeting the one from the opposite side. The action of the lateral pouch is not quite so clear, but as the maxillary moves forward the pouch expands anteriorly and draws water in. The volumes of the pouches, when jaws were retracted, were estimated roughly as three cu. mm. (median) and eight cu. mm. (lateral). A specimen of 107 mm. had seven epithelial folds, and one of 75 mm. had six.

One *Micropterus d. dolomieui* of 235 mm. had thirteen folds.

A specimen of *Lepomis cyanellus* of 120 mm. had twelve folds, almost exactly as figured for *Chaenobryttus*, but the posterior ones slightly more bulbous.

Since the evidence thus far shows that size of the fish and number of folds are correlated, it is of interest to notice the condition in the little sunfishes. A *Mesogonistius chaetodon* of 36 mm. has seven simple short folds, one (most swollen) posterior, and three above and below the central ridge. *Enneacanthus gloriosus* (39 mm.) has five folds similarly arranged.

In *Elassoma zonatum* (23 mm.) shown in Fig. 4 the nasal sac is elongate, the median and lateral secondary pouches are still present, but the folds have failed to develop more than rudimentary form. They may be interpreted as three reduced folds, equivalent to the most posterior ones found in other sunfishes, plus the central ridge which runs forward toward the anterior naris. Thus in this character, as in others peculiar to *Elassoma*, the difference can be attributed to an attainment of sexual maturity while many morphological features are still larval or juvenile. In other words, *Elassoma* is a neotenous sunfish.

Summary: In Centrarchidae there are two accessory pouches opening from the posterior part of the primary nasal sac that act as water pumps during the protractile and retractile movements of the upper jaw. The olfactory epithelium, supplied by branches of the olfactory nerve, is thrown into a series of folds (except in very small individuals) radiating mediad, laterad and caudad from a central ridge. In development the most posterior fold appears first, followed by those above (mediad) and below (laterad) the ridge progressing anteriorly together. In general, the number attained depends upon the size of the fish. In *Archoplites*, *Pomoxis* and *Centrarchus* the folds are paired; alternate ones are swollen. In other sunfishes this pairing has not been found, and either the more posterior, or all, of the folds may be swollen. *Mesogonistius* and *Enneacanthus* show reduction of the number of folds (by failure to develop the more anterior), and in *Elassoma* only three rudimentary folds, and the central ridge, may be seen.—THEODORE H. EATON, JR., *East Carolina College, Greenville, North Carolina.*

REVIEWS AND COMMENTS

GUIDE TO THE REPTILES, AMPHIBIANS, AND FRESH-WATER FISHES OF FLORIDA. By Archie Carr and Coleman J. Goin. University of Florida Press, Gainesville, "1955" (distributed in early 1956): i–ix + 341, 30 figs., 67 pls. $6.50 (paper).—This long awaited book is a fine addition to the limited number of available books on the fishes, amphibians and reptiles of the southern states. The section dealing with fish represents the first modern treatment of a fresh water fish fauna of a southeastern state.

State-wide publications, whether keys, guides or annotated lists written for popular use or not, are often rapidly incorporated into professional literature. The authors have attempted to compromise between the two demands. The "Preface" and "Introduction" are written with an extreme "air of popularity" for the layman, while other parts of the

book are technical. There is a short glossary and labeled set of illustrations preceding each key to the group of animals. The illustrations are informative and adequate for all groups except the turtles, where labeling of a sketch of the plastral laminae would have been helpful. In addition, a brief section is devoted to an explanation of making counts and measurements of fishes. The illustrative keys are of the commonly employed dichotomous, couplet type.

A brief account of each species and subspecies gives scientific and common names, general appearance, distinguishing characters, descriptions, general distribution, Florida range and habitat. This style is followed throughout the three groups treated. The portion of the account called "general appearance" adds little to the value of the total descriptive material. In these days of high printing costs one questions the repetition of species characteristics in the "Description" of more than one of the races of the several polytypic species occurring in Florida, *Diemictylus viridescens* for example.

The numerous half-tone illustrations include nearly all forms of fishes mentioned in the text. Excellent photographs by Roger and Isabelle Conant illustrate many of the amphibians and reptiles. The "Appendix" presents a list of poisonous snakes and directions for giving first-aid treatment of bites.

There are some minor discrepancies as seems inevitable in any book which covers a multitude of details. The authors are inconsistent in their use of geographical and/or physiographical delineations of the general distribution of the amphibian and reptile species. In some accounts the general range given is inaccurate or incomplete, e.g. *Lepomis auritus*, "Maine to Texas" is misleading because the natural distribution does not include the extreme western part of the panhandle of Florida nor any of the area to the west along the Gulf coast. Apparently there is no doubt that the Texas population is the result of introductions. *Lepomis marginatus* is wider ranging than indicated. It occurs west along the Gulf Coast to eastern Texas and lower Mississippi River drainage. *Heterandria formosa* is common in Louisiana around New Orleans on both sides of the Mississippi River and eastward to southwestern Mississippi. This distribution is likely a result of introductions. *Notropis maculatus*, *Menidia beryllina* and *Etheostoma barratti* extend farther westward than indicated. The three species range into Texas along the Gulf coast. Streams draining into the northern Gulf of Mexico were not mentioned for the range of the striped bass, *Roccus saxatilis*.

Populations of *Eurycea longicauda guttolineata* range into Maryland, of *Pseudotriton ruber vioscai* into South Carolina and of *Pseudacris ornata* into eastern Louisiana. The distribution of races of *Desmognathus fuscus* has been variously modified (Grobman, 1950, *Nat. Hist. Misc.*, 70: 1–8). Populations of *Abastor erythrogrammus* occur in eastern Louisiana (Viosca, 1926, *Ecology*, 7(3): 309). Notable omissions include *Necturus punctatus lodingi* and *Natrix sipedon pleuralis*, which are reported to occur in Florida (Neill, 1954, *Publ. Res. Div. Rept. Inst.*, 1(7): 78–96). Until additional collections conclusively reveal their presence in Florida, *Amphuima means tridactylum*, *Carphophis a. amoena* and *Chrysemys p. picta* should be considered as hypothetical residents. The taxonomic allocations of populations of *Acris gryllus* and *Pseudacris* "feriarum" in the panhandle may puzzle the technical reader (cf. Neill, *ibid*).

A few of the fish illustrations are inadequate or incorrect. Three superficially similar species of minnows are rather poorly illustrated, i.e. some diagnostic features are not clearly shown (Plate 10). The dark lateral band is more district anteriorly than illustrated and terminates on the lips and chin of both *Notropis chalybaeus* and *N. cummingsae* whereas this band includes only the upper lip in *Hybopsis harperi*. The lower lip and chin of the latter are usually immaculate. Only 8 anal fin rays are countable in *N. cummingsae* which usually has 10 or 11, rarely 9, never 8 (Hubbs and Raney, 1951, *Occ. Pap. Mus. Zool.*, Univ. Mich.). *Notropis chalybaeus* is shown with 11 anal fin rays which leads one to believe the names or plates of *N. chalybaeus* and *N. cummingsae* were mixed because the former, *N. chalybaeus* usually has 8 anal rays. Plate 12 does not portray the typical body form of *Schilbeodes mollis*. The majority of the remaining illustrations are adequate and will certainly aid in the identification of the fishes of Florida.—ROYAL D. SUTTKUS, *Zoology Department, Tulane University, New Orleans, Louisiana and* ROBERT E. GORDON, *Biology Department, Northeast Louisiana State College, Monroe, Louisiana.*

THE CLUPEIDAE. By A. N. Svetovidov. [Fauna of the USSR, Fishes, Vol. 2, No. 1.] Academy of Sciences Press, Moscow and Leningrad, 1952. 331 pp., 54 text figs., 53 pls. (In Russian.)—This is the second of Svetovidov's large-scale and vitally important monographs of USSR fish groups. Unlike his earlier work on the cods (see COPEIA, 1954: 245) which deals extensively with generic and family classification, the present treatise emphasizes the specific and infraspecific levels of herring systematics. Indeed, while deploring the number of named infraspecific forms of herrings, Svetovidov follows Russian precedent in recognizing quadrinomials. Eleven genera and 56 forms of USSR clupeids are treated in detail. Plates of these and of the crania of many of them are given at the back of

the book, while the text illustrations include details of individual forms, distribution maps, etc.

Probably of greatest importance to the foreign reader is the introductory chapter of 82 pages dealing with the classification, geographical distribution, and biology of the Clupeidae. After pointing out in the foreword that fossil clupeids are, in general, too poorly known to permit a sound integration between the classification of recent and fossil forms, Svetovidov devotes pp. 9–35 and 91–99 to the classification of the modern Clupeidae on a worldwide basis. Six subfamilies are recognized: Dussumieriinae, Clupeinae, Pellonulinae, Alosinae, Dorosomatinae, and Pristigasterinae. Svetovidov's approach to clupeid systematics is, to the reviewer at least, highly interesting (p. 11). "A classification, as the author has repeatedly emphasized (1946: 183; 1948: 19), ought to be based on a complex of morphological features functionally connected with the most characteristic biological peculiarity of the systematic group under consideration and resulting from the interaction between the organism and its environment. Most often the ensemble of morphological features at the base of the system for a group being studied is connected with movement and place of abode in the different portions of the aquatic environment, more rarely with feeding, sometimes with reproduction. A change of the complex of morphological peculiarities in a group is usually attended by changes in ontogenetic development in that group. Therefore, it is especially important to take into consideration the data of ontogenesis, which usually provide a point of departure for the construction of the system of classification." The remainder of the systematic section of this chapter is devoted to an application of the above principles to herring taxonomy. The 32 following pages deal with the geographical distribution of the Clupeidae. This subject is taken up from an historical viewpoint and traces the effects of Tertiary and Quaternary changes in climate, physiography, and salinities on the development of modern fish faunas, with particular reference to Eurasian clupeids. The next section of 12 pages deals with the biology and ecology of the herrings. Especially novel to the reviewer is the possibility mentioned by Svetovidov (p. 73) that certain clupeids may be influenced by electrical currents existing normally in the water. The chapter closes with a three page account of the commercial importance of the group and with a bibliography of 105 Russian and 103 non-Russian citations.—WILLIAM A. GOSLINE, *University of Hawaii, Honolulu, T. H.*

GUIDE TO TROPICAL FISHKEEPING. By J. H. P. Brymer. Walter Life. Dorset House. Stamford Street. London S.E.I. 1954. xvi + 336 pp., illus. $4.90. This book on the hobby of tropical fishkeeping is organized in 12 chapters consisting of: 1, general considerations of equipment; 2, aquarium plants; 3, snails, algae and predators; (discussed largely in respect to Great Britain); 4, causes and symptoms of ill-health; 5, cleaning the aquarium; 6, properties of water; 7, feeding; 8, community collections; 9, breeding; 10, identification; 11, classification; and 12, a systematic account of tropical fish. Notes on terms, safeguards when using electricity, a bibliography and 4 indices complete this useful manual. The illustrations are well done, notably the 6 colored plates and 24 color photographs which will help in the identification of tropicals.

The 377 species described in the systematic section belong to 175 genera and 36 families following Regan's classification. Each description includes: scientific and common names of fish; native countries; size, shape and color; and factors on keeping the particular species successfully. That no key to the species of aquarium fish is included is unfortunate. One can only thumb through the pages and refer to the pictures and descriptions of the species in attempting an identification. This is possibly not a serious omission for the fish keeper and is made up by the superior illustations. The first nine chapters will undoubtedly be very helpful to the beginner in setting up and maintaining an aquarium.—ROBERT K. CHIPMAN. *Department of Zoology. Tulane University.*

EVOLUTION, GENETICS, AND MAN. By Theodosius Dobzhansky. John Wiley and Sons, Inc., New York, 1955: ix + 398. $5.50.—A leader in modern biological evolution with a gift for lucid writing has produced an undergraduate text that illuminates the principles of evolution from a dynamic point of view. The student is not burdened with a wearisome tabulation of dry facts generally considered in an undergraduate course under the heading of "evidence of evolution," but is treated to a comprehensive and well-balanced exposition of current evolutionary concepts and of the impact of genetics upon evolutionary thought and research.

The early chapters present the principles of genetics essential to an understanding of modern evolutionary tenets. Subsequent chapters contain a discussion of the factors that result in changes in the genetic composition of populations and the manner in which these factors interact to mold the structure of populations into new shapes. The author describes the processes leading to the formation of races and species, the origin and operation of reproductive isolating mechanisms, the rapid, almost cataclysmic, origin of certain plant species by polyploidy, and man's influence on the evolution of domesticated animals and plants. A consideration of the concepts of homology and analogy precedes

a discussion, in the closing chapters, of the structural and functional modifications of organisms throughout the ages. The past history of man is reconstructed concisely.

It is the hope of the author that the text "may be useful not only as a guide in courses devoted to the study of biological evolution but also as collateral reading in courses of general biology, general zoology, general botany, and anthropology." A simple, yet scholarly, manner of presentation, a generous provision of clear, attractive illustrations, a helpful list of suggested readings, an excellent choice and organization of material, an adequate index, and a good size of type, all contribute to making the text admirably suited to its purpose.—E. PETER VOLPE, *Department of Zoology, Newcomb College of Tulane University, New Orleans, Louisiana.*

THE PRESERVATION OF NATURAL HISTORY SPECIMENS, VOLUME ONE. INVERTEBRATES. Edited and compiled by Reginald Wagstaffe and J. Havelock Fidler. Philosophical Library, Inc., New York and Edinburgh. 1955: xiii + 205, 139 figures. $10.00.—The editors have drawn on previously published material, have included accounts expressly prepared for the volume, and have written down for the first time their own previously unpublished methods. They have placed emphasis on those techniques known to preserve permanently the most important features of each group.

All material is treated systematically in 21 chapters following the scheme of classification and nomenclature outlined in the 2nd edition of *The Invertebrata* (1941) by Borradaile, Eastham, Potts and Saunders. Chapters headings are: Protozoa (other than Foraminifera and Radiolaria), Foraminifera, Radiolaria, Porifera, Coelenterata, Platyhelminthes, Nemertinea, Rotifera, Nematoda, Annelida, Onychophora, Crustacea, Insecta, Arachnida, Mollusca, Polyzoa, Brachiopoda, Chaetognatha, Echinodermata and Tunicata. Five appendices deal with Apparatus and Instruments, Reagents, Labels and Labelling, Storage, and Microscopy.

For each Class (or Order in the Insecta) there are usually included methods for narcotizing (if necessary), killing and fixing, preservation (wet and dry methods), and mounting. Special techniques are described for dissection and preservation of parts of certain animals, methods for preserving immature forms, eggs, and fossils.

The book is a "must" for curators and professional collectors who must handle a wide variety of materials.—GEORGE HENRY PENN, *Department of Zoology, Tulane University, New Orleans, Louisiana.*

FISHES OF WESTERN ARCTIC AMERICA AND EASTERN ARCTIC SIBERIA. By Vladimir Walters. American Museum of Natural History Bulletin, 106 (5), 1955: 255-368, 4 maps. $1.50.—All students of the ichthyofauna of the Arctic will welcome the appearance of this published version of Walters' Ph.D. thesis that was submitted to New York University.

The author has clearly defined the geographic boundaries of the area studied. The work specifically deals with the marine and freshwater fishes occurring in the coastal and fresh waters between 105°E. longitude and 105°W. longitude, including "the drainages of the east Siberian and Chukchi seas of Siberia, the drainages of the Chukchi and Beafort seas of Alaska and the arctic watershed of Canada east to 105°W."

Nomenclatorially, the suprageneric classification follows that of Berg (1940). The author has offered definitions for the generic and the subgeneric categories. A key to 66 species of fishes of the marine and freshwaters is presented, but the coverage of freshwater fishes is restricted to Arctic Alaska. The key was constructed primarily for the identification of Alaskan fishes and is probably quite adequate for that purpose. In places, however, the key seems unnecessarily brief, for example:

"18a Adipose fin with light spots....*Salvelinus namaycush* (Lake Trout).

18b Adipose fin without light spots....*Salvelinus alpinus complex* (Arctic Charrs)."

An annotated list covering 89 fishes follows the key. This section is especially valuable. Each species has been treated under the following headings: range, previous records, specimens seen, and notes. The subsection entitled "Notes," has been used for discussion of problems arising from a consideration of the particular species, such as comparison of North American and Asiatic representatives of a species. The approach to complex nomenclatural problems is generally realistic; for example, all alpinoid chars are referred to *Salvelinus alpinus* in the light of the inadequacy of our present knowledge of these fishes. Considerable space has been devoted to the coregonid fishes (here considered as a subfamily *Coregonini*). The author follows the school of thought that prefers to lump the genus *Leucichthys* with *Coregonus*, reducing *Leucichthys* to subgeneric status. The three coregonid genera recognized are, *Stenodus*, *Coregonus*, and *Prosopium*.

Many changes of specific names have been proposed, most of them supported by comparative data; for example, the North American form of the grayling is reduced to a subspecific form of the Asiatic species and is designated as *Thymallus arcticus signifer*. Similar treatment has been given to *Osmerus eperlanus dentex*. The Greenland cod, herein referred to as ogac, is considered only sub-

specifically distinct from *G. morhua*, hence is referred to as *G. m. ogac*. In this reviewer's opinion the retention of specific status for this species would be desirable, but differences of opinion on such problems, will, it is hoped, always exist.

Unfortunately, the author has frequently deviated from the common names recommended by the American Fisheries Society, and has used such names as shee (inconnu or coney), hump-backed whitefish (lake whitefish), sailfin grayling (American grayling), grey sucker (white sucker), and others. In view of the many proposed changes in scientific nomenclature for North American fishes, stability in the vernaculars is more desirable than ever.

Following the annotated list is a chapter entitled "Discussion," which includes such subjects as, climatic changes, water temperature and salinity, invasion of new areas, avenues of dispersal, the ichthyofauna (freshwater and marine listed separately), geology and zoogeography, and the existence and disappearance of Bering Strait land bridge (treated by stages).

One of the most valuable contributions that Walters has made concerns the consideration given to the works of Asiatic and European investigators. The integration of the findings of Eurasian and North American workers has resulted in a more comprehensive approach to the problems of taxonomy and zoogeography of arctic fishes than has been available heretofore. Some indication of the extent of literature coverage may be gained from the fact that the bibliography contains 190 references, 25 of them Russian.—W. B. Scott, *Royal Ontario Museum, Department of Ichthyology and Herpetology, Toronto 5, Ontario, Canada.*

PAPERS IN MARINE BIOLOGY AND OCEANOGRAPHY DEDICATED TO HENRY B. BIGELOW. Pergamon Press, London and New York, 1955. Issued as a supplement to volume 3 of *Deep-Sea Research*: xx + 498, illus. $10.50.—Of the 48 included papers, 11 deal primarily with fishes. All but 4 of these 11 are concerned with fishery resources.

UNSERE SÜSSWASSER FISCHE. By Otto Schindler. Frankh'sche Verlagshandlung, Stuttgart, 1953: 225 pp., 32 pls. DM 12.80.—Over half of this attractively printed little handbook is devoted to an account of fish biology.

CLASSIFICATION OF FISHES, BOTH RECENT AND FOSSIL. By L. S. Berg. Second edition, revised and enlarged. Transactions of the Zoological Institute, Academy of Sciences of the USSR, Moscow and Leningrad, vol. 20, 1955: 286 pp., 263 figs. (In Russian.)—At the time of his death Berg had systematically revised chiefly the portions on fossil fish groups. This section has been considerably expanded, with many new illustrations added. Other changes, aside from the disappearance of the English translation at the rear of the first edition, are minor. The old classification has been retained; the printing of the figures has been improved; and an author index and synoptic classification have been added.

AMPHIBIANS AND REPTILES OF GEORGIA. By Bernard S. Martof. University of Georgia Press, Athens, Georgia, 1956: vii + 94 pp., 58 figs. $2.00.—An illustrated key designed for the amateur and to promote more intensive exploration of the herpetofauna of Georgia.

GRASSLANDS OF THE GREAT PLAINS, THEIR NATURE AND USE. By J. E. Weaver and F. W. Albertson. Johnsen Publishing Co., Lincoln, Nebraska, 1956: ix + 395 pp., 91 figs.

A COLORED ATLAS OF SOME VERTEBRATES FROM CEYLON. VOL. 3, SERPENTOID REPTILIA. By P. E. P. Deraniyagala. National Museum, Colombo, Ceylon, 1955: ix + 199 pp., 21 pls. (14 colored).

FRESH WATER FISHES OF NEW ZEALAND. By G. Stokell. Simpson and Williams, Ltd., Christchurch, New Zealand, 1955: 145 pp., illus.

THE COMMERCIAL FISHES AND FISHERIES OF QUEENSLAND. By J. Douglas Ogilby. Revised and illustrated edition. Fisheries Branch, Department of Harbours and Marine, Brisbane, Queensland, 1954: viii + 121, 123 figs.

PECES DE IMPORTANCIA COMERCIAL EN LA COSTA NOR-OCCIDENTAL DE MEXICO. By Julio Berdegue A. Direccion General de Pesca e Industrias Conexas, Secretaria de Marina, Mexico, 1956: 345 pp., 206 figs., 1 map.

Editorial Notes and News

University of Stellenbosch Zoological Institute

The herpetological work of the Institute is concerned chiefly with the study of various comparative embryological and morphological problems. A paper on the general cranial morphology of *Ambystoma macrodactylum* has recently appeared and a similar one on *Scolecomorphus uluguruensis* is in preparation. The more advanced work deals with the relationship between the visceral skeleton and the neurocranium, the origin and evolution of the components of the sound-conducting apparatus and the morphology of the nasal capsule and nasal cavities with special reference to the microranid genera of South Africa. A comprehensive paper on the ontogenesis of the sound-conducting apparatus of *Bufo angusticeps* is in press and similar work on *Heleophryne* is in progress.

The remarkable American genus *Ascaphus* has been studied from various angles in this Institute, Such studies entail minute research on the skeleton. and more particularly the phallic organ, sometimes known as the "tail". A paper on the histological and anatomical details of this organ has just appeared. In a paper in preparation on the end-gut as an organ of intromission, the general problems regarding the morphology of all organ systems entailed in the vicinity of the cloacal opening will be discussed.

Research on the general cranial morphology of the lacertid genus, *Eremias*, is in progress. A more comprehensive work on the development of the skeleton and muscles of the shoulder girdle, sternum and ribs of the chamaeleon *Microsaura pumila* has been started. Some experimental work is also being done on the gastrulation of the mountain tortoise.

The Institute has not been active in the field of ichthyology in recent years. Currently one D.Sc. student, on the staff of the Division of Fisheries, is engaged in long term research on the correlation between zooplankton-phytoplankton and the pilchard (*Sardinops ocellata*) and maasbanker (*Trachurus trachurus*) populations off the west coast of the Union of South Africa.

Texas Herpetological Society

The annual meeting of the Texas Herpetological Society was held near Nacogdoces, Angelina County, Texas, May 4–6, 1956. Excellent camping facilities were provided in the Stephen F. Austin Experimental Forest south of Nacogdoches for the approximately 90 members in attendance.

The following officers were elected: President, William K. Davis; Vice-President, J. H. Tabony, Jr.; Secretary-Treasurer, W. A. Thornton.

Mexican Society of Hydrobiology

The society was reorganized during its third annual meeting in Mexico City, April 17 to April 21. The fourteen papers presented included the results of researches on fresh water and marine biology, paleontology and fisheries. The following officers were elected: President, Manuel Maldonado-Koerdell; Secretary, Jorge Carranza; Treasurer, Carlos García; Permanent Secretary, José Alvarez.

Any aquatic biologist may become a member of the society. The annual dues are $1.50.

Annual Meeting Southeastern Division

The Sixth Annual Meeting was held in conjunction with the meetings of the Association of Southeastern Biologists at Duke University, Durham, North Carolina, on April 20, 1956. The following papers were presented:

Trends of Variation In the Gulf Pipefish, *Syngnathus scovelli*.—Edwin B. Joseph, Florida State University.

The First Mola *Mola* Collected from the Gulf of Mexico.—Hurst Shoemaker, Gulf Coast Research Lab., and Harvey Bullis, U. S. Fish and Wildlife Service.

A Ceratioid Angler New to the Gulf of Mexico, with Three Parasitic Males.—Hurst Shoemaker and Gordon Gunter, Gulf Coast Research Laboratory.

Geographic Variation in the Brook Lamprey *Lampetra aepyptera* (Abbott).—William M. Clay, Univ. of Louisville.

An Annotated Check List of Tennessee Amphibians and Reptiles.—Glen Gentry, Tennessee Game and Fish Commission.

A Bibliography of the Herpetology of Eastern North America.—Wilfred T. Neill, Research Div., Ross Allen Reptile Institute.

Notes on Food of *Coluber constrictor* in the Carolinas.—E. E. Brown, Davidson College.

The Status of *Plethodon jacksoni* Newman.—Victor H. Hutchison, Duke University.

The following officers were elected for the year 1957: President, Wilfred T. Neill (Research Division, Ross Allen Reptile Institute); Vice-President, Donald C. Scott (University of Georgia); Secretary-Treasurer, E. E. Brown (Davidson College).

J. R. Norman's Unpublished Synopsis

The late J. R. Norman left in manuscript a synopsis of orders, families and genera of modern fishes covering the classes Marsipobranchii, Selachii and

Pisces (Regan's classification), omitting the Orders Ostariophysi and Scleroparei and the Family Cichlidae. He took into account all literature up to 1938, and all that was available to him during the war years to 1944. Classes are defined and keys are given to orders, suborders, divisions, families and genera. Generic synonyms and type species are given, with references, and monographs of families and larger groups are mentioned.

This work is not considered suitable for publication. Not only is it fifteen years out of date, but naturally not all the groups are treated critically enough. It is, however, such a useful working tool that many may desire to possess a copy.

There are 606 typed foolscap pages; an index will be made. If orders are received for 40–50 copies, they can be produced by photo-lithography or by stencil, and supplied in a strong loose-leaf binder for approximately $26.50 per copy. Of this total, $2.80 is the cost of the index. If only 20 copies are ordered, the price will be $42.00.

Individuals or representatives of institutions interested should write to the Director, British Museum (Natural History), Cromwell Road, London, S.W. 7, in words like the following:

If loose-leaf copies of Norman's "Synopsis" are made available I intend to purchase a copy, with index; I understand that the price will be $26.50.

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Further information regarding this work may be obtained from Dr. E. TREWAVAS.

Book Reviews and Notices

The editors desire to print reviews and notices promptly after publication. This is not possible unless authors insure that review copies of major monographs, reports or books are sent to the Editor-in-Chief immediately after publication. Cooperation of author members will aid much to insure early publication.

News Notes

Dr. K. P. SCHMIDT, Chicago Natural History Museum, was elected to membership in the National Academy of Sciences at its 93rd annual meeting.

Dr. GEORGE S. MYERS, Stanford University, has recently been elected an Honorary Corresponding Fellow of the Zoological Society of India and a Foreign Member of the Sociedad Linneana de Sincelejo, Bolivar, Colombia.

Dr. JAMES A. PETERS has been studying the Ecuadorian herpetological materials in the Stanford University Natural History Museum. His work is supported by a grant from the National Academy of Sciences.

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The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

Back numbers of COPEIA, as available, may be procured from Prof. N. B. Green, Biology Dept., Marshall College Huntington, West Virginia. Prices will be furnished on application.

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